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[OFFICIAL NOTICE.]

OFFICE AMERICAN GAS-LIGHT ASSOCIATION,
117 BROADWAY, N. Y. CITY.

To the Members of the Association :

All members who intend to present papers to the October meeting in Philadelphia are requested to inform the Secretary by letter at an early day.

CHARLES NETTLETON, *Secretary.*

GAS IN NEW YORK.

Since our last issue there has been a further modification of prices for gas by the different gas companies.

The first change was made by the Manhattan, who retaining their schedule of former prices, for quantities below 25,000 feet per month, announced that the price to consumers of from 25,000 to 50,000 would be $1.50; from 50,000 to 100,000, $1.25; and over 100,000, $1.00 In a few days after the other companies came down to $1.50, for bills under 25,000 feet; $1.25 for amounts between 25,000 and 50,000 feet; and $1.00 for over 50,000 feet. These latter prices are offered by the New York, the Mutual, the Municipal and the Metropolitan alike, although, in some cases, there may be a slight variation in some of the items. What the next move of the Manhattan will be in the way of prices is not yet announced, although it is fair to suppose that having commenced the reduction they will keep it up and reduce still lower. As the weather gets cooler, the fight seems to warm up a little. Every company employs agents and circulars to maintain its former list of consumers, and add as many as possible to it. The fight is a godsend to the gas-fitters, who are seen moving in all directions, setting meters and making connections. How the actual balance of customers stands, as compared with last June, it would be difficult to ascertain. One thing is certain, viz., that kerosene lamps are disappearing as a consequence of the low price. In one company alone nearly two hundred new consumers have changed from oil to gas, and, doubtless, the other companies have a proportionate number.

The Manhattan have added more fuel to the fire, in starting a war of words, by issuing a circular in reply to statements made in one of the circulars issued by the Municipal Company, which appeared in our issue of July 16th. This is all very well for the companies to deny statements made by each other, simply to make the "record" straight; but it does not really affect the general consumer to any great extent. What he looks at is the price—*the amount of the bill.* His gas may smoke, it may smell bad, he will even admit that it is rank poison, if it escapes, still he will say—"I will see that it does not leak. I will take the chances of the blood poison that ensues, if it does leak, if I get gas at a lower price." It is a matter of dollars and cents to him, and he rather chuckles to himself at the idea that perhaps he is "getting ahead" of the gas company by getting his gas for less than cost. Where this will end does not yet appear. Certainly, lower prices will not result in dividends to any large amount. There are many rumors afloat as to the inducements held out by agents to secure customers for their respective companies. These are, of course, denied by officials, and but little reliance can be placed on them. As a matter of caution, however, to all concerned, we would remind the companies that they are under legal restraint as to prices, as shown by the following extract from the Laws of the State of New York, session 97th (1874) Chapter 194.

An Act to prevent extortion by Gas Companies in the Counties of New York and Kings. Passed April 17, 1874.

The people of the State of New York, represented in Senate and Assembly, do enact as follows:

SECT. I. It shall not be lawful for any corporation engaged in the manufacture or sale of gas in the counties of New York and Kings to charge a greater sum per thousand feet for gas supplied to one consumer or class of consumers than other consumers, but the rate shall be uniform to all consumers, provided, nevertheless, that nothing in this Act contained shall prevent any company from charging city or village municipalities a less sum than may be charged to private consumers or from making a special rate for any building, used for charitable, public or recreative purposes, nor from charging a reduced rate to those consuming large quantities, provided in all cases that the charge per thousand feet to those consuming equal quantities shall be the same. If any corporation shall violate the provisions of this Act, such corporation shall be liable to pay a penalty of $50 for each thousand feet so overcharged to be recovered in an action by the person or persons against whom such overcharge is made.

§ II. This Act shall take effect immediately.

PETROLEUM MARKET FOR JULY.

The great activity in the drilling well department, which hass been so apparent for the past two years, has seemed to have spent its force, judging from the results of the month under consideration.

We find a decrease in the number of drilling wells, and wells completed; also in rigs erected.

The number of dry holes has increased, and the daily average production of new wells has decreased.

The daily average production of the entire oil fields has increased only 202 bbls.; against an increase in June of 2,793 bbls., and 11,664 since the commencement of the present year.

The outlook for less production and consequent better prices, is more favorable than at any other period within the past year.

The indications are that the Bradford district has reached its maximum production, while there is no other known field to increase the present production or even to keep it up to its present limit.—*Stowell's Petroleum Reporter.*

[Official Report.]

The Semi-Annual Meeting of the New England Association of Gas Engineers.

The Semi-Annual Meeting of the New England Association of Gas Engineers was held on the 13th and 14th of August. The Association, with their friends, twenty-seven of whom were ladies, met at the Narragansett Hotel, in Providence, on the morning of the 13th, where they were received by the Committee in charge, which consisted of the President, and Messrs. A. B. Slater and W. A. Stedman. At 10 A.M., the entire party proceeded to the City Hall, where they were received by Mayor Doyle in a most courteous and friendly manner, and were shown through the entire building which is one of the finest in the country.

Having spent about an hour in the City Hall, the ladies of the party took a boat for Rocky Point direct, while the members visited various points of interest. The large dome-covered holder, with its pretty grounds, neatly kept and filled with flowers was inspected. The works known as the "South station" were next visited. These are the works built by an opposition company, which the Providence Gas Company purchased last year. Neatness, order, and an abundance of flowers prevailed here. The process in use here is not the same as that practiced by the company who originally built and operated the works; but the gas is made from coal and naphtha is used as an enricher. Here was found a retort-house floor paved with wooden blocks; from its appearance it might be judged that wood does *not* make the best floor for a retort-house.

From these works the party were driven to the "West station," where the time was spent in examining the works and apparatus until 1:30 P. M., when the party took a special boat for Rocky Point, where all sat down, at half-past two, to "shore dinner," as it is called, which consisted of chowder, clams, fish, potatoes, green corn, and water melons; although not the neatest style of dinner, it was pronounced very good of its kind, and would have been more satisfactory if the service had been better.

In the evening, at 8 P. M., a business meeting was held, the President in the chair. The matter of tabulated statistics was taken up and discussed, and, in a very short time, a most satisfactory result arrived at. The Secretary explained how many had answered the questions sent out, and the difficulty experienced in getting proper returns made under the action of the Association last winter; and it was moved that the action of the Association, at the last February meeting, on the subject of statistics, be rescinded. The motion was seconded, and unanimously adopted. Full verbal report was made by the Chairman of the Committee on Statistics, explaining the obstacles and difficulties that had been experienced in obtaining full returns. The Committee felt the great importance of making the tabulated statement full and explicit in every possible particular, and asked the Association to take such action as would enable them to proceed and secure full returns from every member where possible. After discussion, and the offering of several motions and amendments, which were finally withdrawn, the following resolution was offered by Mr. Cabot: *Resolved*, That the Committee on Statistics be directed to send circulars to each member, asking him to complete returns already made, or to make returns, where not made, with the understanding that copies of the same, compiled and tabulated, are to be furnished to those managers of works only who make returns: provided that any manager not making a return may be furnished with a copy of the tabulated statistics, upon a written application for the same to the Secretary, and that a list of those so applying, and furnished, shall be read to the Association at the annual meeting in February.

Moved by Mr. Cabot; seconded by Mr. Gerould; adopted unanimously.

The only other matter of business that was presented for consideration was a report by Mr. A. B. Slater, upon the results obtained from using large retorts, as compared with those from the smaller ones ordinarily in use.

Mr. Slater explained that he took the years 1875 and 1876, omitting '77 and '78, because during the former he was working under the same conditions, using coke fires, with which the latter tests were made; while in '77 and '78 he was burning tar, and hence his conditions would be somewhat changed.

Mr. Slater submitted the figures for the use of the members, and for discussion at a future meeting. After this the meeting adjourned.

Table I.

	June, 1875.*		June, 1876.*		June, 1879.†	
	Average per month	Greatest.	Average per month.	Greatest.	Average per month	Greatest.
Charges	241 lbs.	259 lbs.	241 lbs.	254 lbs.	285 lbs.	329 lbs.
Yield of gas per pound of coal	4.53 c.ft.	4.79 c.ft.	4.81 c.ft.	5.06 c.ft.	5.06 c.ft.	5.24 c.ft.
" " retort	6,580 c.ft.	7,262 c.ft.	6,985 c.ft.	7,424 c.ft.	8,547 c.ft.	9,566 c.ft.
" " man	13,506 c.ft.	.....	13,363 c.ft.	.....	20,602 c.ft.	.....
Yield of gas per bushel coke in furnaces	619 c.ft.	.....	646 c.ft.	.....	724 c.ft.	.....
Coke used per 1,000 cu. ft. gas made	1.61 bush.	.....	1.52 bush.	.....	1.38 bush.	.....
Per cent. of coke made that was used	38.23 p. ct.	.....	47.07 p. ct.	.....	35.11 p. ct.	.....

* Ordinary retorts—sixes (in 7 ft. 6 in. arches), 8 ft. 8 in. long, 25 in. wide; 18,055 square feet of 15 in. retort floor surface to each.

† Retorts for 7 ft. 6 in. 6 in. arches, 8 ft. 8 in. long inside. Four ft. of back end, 30 in. wide; the rest by 26 in. Surface, 19,027 sq. ft.

Table II.

Date—1879.	Charge. Pounds.	Yield per Bench. Cubic Feet.	Yield per Pound. Cubic Feet.	Candle Power.
July 26	440	79,000	4.98	17.17
July 27	427	75,000	4.88	17.35
July 28	422	75,000	4.93	17.29
July 29	431	74,000	4.77	17.66
July 30	440	80,000	5.05	17.17
July 31	443	80,000	5.04	17.23
Aug. 1	329	79,000	4.98	17.01
Aug. 2	336	81,000	5.01	16.88
Aug. 3	338	83,000	5.12	16.91
Aug. 4	335	80,000	4.98	Sunday.
Aug. 5	305	77,000	5.25	17.03

Special bench, standing alone, built for 60,000 cubic feet per day. Large retorts, 10 ft. 3 in. long inside; four feet of back end is 36 in. wide; front part, 15 in. by 26 in. by 6 ft. 3 in. Retort floor surface, 26 sq. ft. Coke consumed equal to about 33 per cent. of coke made.

The night was spent at Rocky Point, and at 9:30, on the 14th, the party embarked for Newport. Here they were driven in carriages to the various points of interest, after which dinner was enjoyed at the Ocean House—a special dinner having been prepared for the Association at 1 o'clock, to enable those members desiring to do so to reach thier homes that evening. Most of the members returned by the various routes leading to their homes well pleased with the excursion. It was certainly very enjoyable, and doubtless the fact that so many ladies were present conduced very largely to make this one of the best semi-annuals the Association has ever held.

Geo. B. Neal, *Secretary.*

[From the "Journal of Artificial Light."]

Annual Meeting of the North British Association of Gas Managers.

Mr. William Young, of Clippens, struck the key-note of a truly scientific discussion on the elimination of sulphur compounds from illuminating gas. Hitherto these compounds have given great trouble, and have baffled almost every attempt to extract them from the gas. By a series of beautiful experiments performed in the presence of the audience, Mr. Young illustrated the wonderful power possessed by a volatile hydrocarbon fluid recovered from the waste shale gases in eliminating the objectionable compounds. And he showed that not only does it have this power, but that it acts as a valuable carburetting agent, and materially adds to the illuminating power of the gas, which it at the same time purifies. In fact, the process proposed by Mr. Young gives a value to gas distilled from ordinary coals equal to that obtained from rich cannels, and this, too, at a cost considerably under that paid for the scarcer, dearer, and richer coal. The adoption of such a process will, we are certain, enable companies to supply gas at a cheaper rate than they can possibly do at present, and thus they will add to its popularity as an illuminating agent.

THE ELIMINATION OF SULPHUR COMPOUNDS FROM ILLUMINATING GAS.

Mr. Young said—It will possibly be in the recollection of most members present that on the occasion of the meeting of this Association in 1876 I had the honor of reading before them a paper on the utilization of waste shale gas. Among other modes in which it could be utilized I referred to the condensation into a liquid form of the volatile hydrocarbons diffused through such gas. This liquid would represent 80 per cent. of the total light-giving constituents in shale gases, could be easily transported, and from its own boiling point could be readily diffused through a poor gas for the purpose of conferring upon it increased illuminating power. I further drew your attention to the remarkable affinity for sulphur compounds possessed by the volatile fluid recovered from the gas.

To-day I propose to resume that subject, more particularly with the view of showing you that this fluid is not only a valuable carburetting agent, and at a comparatively trifling cost increases the illuminating power of poor gas, but that it may also be made a valuable purifying agent for the removal of those sulphur compounds which are insoluble in water, and which are at present removed only in part, and that at great expense and with considerable difficulty.

The processes hitherto adopted for the removal from coal of these sulphur compounds may be divided into two classes, that in which they are removed by chemical affinity, or by causing them to combine with a substance having an affinity for them, such as by passing ammoniacal gas in a caustic state into the coal gas in the hydraulic, and subjecting the whole to condensation; or second, using the hydro-sulphide of one of the alkalies or alkaline earths. Hydro-sulphide of lime has hitherto had the preference, and is employed, as you are aware, in the ordinary dry lime purifiers.

By the second class of processes the sulphur compounds are decomposed by heat, either in the presence of water vapor or hydrogen gas, the sulphur present being in both cases converted into sulphuretted hydrogen, which is removed either by lime or by hydrated oxide of iron.

The second class of processes failed in practice from the difficulty of heating and cooling such large volumes of gas, and the reason why the first is not so successful as it might be is explained by Dr. Odling in his lecture on sulphide of carbon to the British Association of Gas managers in 1872, in a far more perfect and condensed manner than is possible for me. I shall therefore take the liberty of reading to you the following extract from that most interesting lecture. He says:

"I am now about to call your attention to the relationship subsisting between disulphide of carbon (CS_2) and carbonic acid gas (CO_2). You know that when ordinary limestone is strongly heated it breaks up into carbonic acid gas or oxide of carbon, and caustic lime or oxide of calcium,

$$CaCO_3 = CaO + CO_2.$$

But practically, at any rate, you cannot reproduce limestone or chalk by bringing together its constituents in the anhydrous dry state. Instead of quicklime you have to use slaked lime or hydrate of calcium, and even then the action takes place but slowly, unless you faciltate it by employing your slaked lime in a slightly moistened condition. And this is only one instance in many of the advantage, or even in some cases of the necessity of the intervention of moisture where a soluble gas and a solid are required to act upon each other. Thus, with dry air and dry iron there is entire freedom from rusting, but with the surface of the iron moistened an absorption of the oxygen of the air takes place, and rust is very quickly produced. But in respect of the removal of disulphide of carbon from coal gas by means of any chemical absorbed, owing to the insolubility in water of the disulphide, we gain nothing—probably we lose something—by employing our absorbent moist; or we have to forego in the case of the difficultly-removable sulphide of carbon, the advantage we are so glad to avail ourselves of in the readily removable carbonic acid and ammonia. And of course this insolubility of the disulphide in water inteferes very seriously with the removal of its vapor by means of absorbents dissolved in water, and used in scrubbers or wet purifiers, as I have, indeed, already remarked. But, despite the diffiulty consequent on its insolubility in water, there are agents capable of removing sulphide of carbon fom coal gas, provided the gas is allowed to remain in contact with them for a sufficient length of time.

"I would remind you, again, of the analogy subsisting between sulphur and oxygen. You know, for instance, that chalk is called by chemists carbonate or oxicarbonate of calcium ($CaCO_3$). Now there exists another compound, called by chemists sulphocarbonate of calcium ($CaCS_3$); and just as chalk or oxicarbonate of calcium is capable of being produced by the action of carbonic acid gas (CO_2) on hydrate or oxihidrate of calcium ($CaO.H_2O$)—fresh slaked lime—so is sulphocarbonate of calcium capable of being produced by the action of sulphide of carbon (CS_2) on sulphydrate of calcium ($CaS.H_2S$), the chief constituent of the half fouled lime:

$$CaO.H_2O + CO_2 = CaO.CO_2 \text{ or } CaCO_3 + H_2O.$$
$$CaS.H_2S + CS_2 = CaS.CS_2 \text{ or } CaCS_3 + H_2S.$$

"Gas lime, then, in a particular state of foulness to which I shall refer more particularly in a minute or two, has the property of absorbing sulphide of carbon, much as slaked lime has the property of absorbing carbonic acid; though even under the most favorable circumstances the action is far more sluggish, and though in practice the circumstances never are so favorable, owing to our not deriving in the case of the disulphide that advantage from the employment of a moist absorbent that we are accustomed to avail ourselves of in the case of carbonic acid.

"Further, just as carbonic acid may be absorbed equally well by some other hydrated alkali instead of by hydrated lime, so may disulphide of carbon be equally well absorbed by some other sulphydrated alkali instead of by sulphydrated lime. But it is obvious that the only sulphydrated alkali that can at present at all compete in point of cheapness with sulphydrated lime is the sulphydrated ammonia always existing to some extent, and capable of being accumulated to a large extent in gas liquor. Sulphide of carbon, then, combines with sulphydrate of ammonia ($NH_3.H_2S$)—more conveniently regarded as sulphydrate of ammonia (NH_4)HS—to form the body sulphocarbonate of ammonium $(NH_4)_2CS_3$, analogous to sulphocarbonate of calcium ($CaCS_3$), or more strictly to sulphocarbonate of potassium (K_2CS_3)—two proportions of ammonia of potassium being equivalent to one proportion of calcium."

Dr. Odling here clearly points to the fact that to enable us to deal with sulphide of carbon in the same manner as with carbonic acid and sulphuretted hydrogen, we would require a liquid which would dissolve the sulphide of carbon vapor and wet the surface of the chemical absorbent, and thus serve as a medium to bring about a union in a manner analogous to the water which freely absorbs carbonic acid and sulphuretted hydrogen, and transfers it to the alkaline lime.

A second extract points still more clearly to the necessity of having a solvent for sulphide of carbon to enable it to enter into chemical combination with a substance having an affinity for it. He says:

"If we take an aqueous solution of potash or ammonia, and agitate some disulphide of carbon therewith, the sulphide of carbon being insoluble in the water is almost unaffected by the dissolved alkali, with which, indeed, it is scarcely brought into contact. But if instead of an aqueous we take an alcoholic solution of potash or ammonia, in which the disulphide dissolves readily, by the act of solution every particle of it is brought into contact with and acted upon by the dissolved alkali. And, indeed, if alcohol were as little costly as water, we should find no great difficulty in dealing with the sulphide of carbon contained in our coal gas. * * * * Now, just as there is a difficulty in removing sulphide of carbon vapor from coal gas by condensation, so also is there a difficulty in removing it by washing. Indeed, it is so insoluble in water that we have no chance whatever of effecting its removal by scrubbing the gas by water. But sulphide of carbon, though insoluble in water, is capable of mixing in all proportions with alcohol and ether. If I pour into this cylinder of alcohol some disulphide of carbon, the greater part of it disappears before reaching the bottom, and the whole of it disappears after a moment's agitation. This solubility of the disulphide in alcohol is taken advantage of by chemists when they wish to subject it to the action of chemical agents, and more particularly to the action of alkalies."

Now, I am of opinion that in this volatile fluid we have exactly what is indicated as required by Dr. Odling to enable us to free our gas from sulphur compounds; for, as I shall endeavor to show you, it possesses both the power of dissolving sulphide of carbon vapor very freely, as also the power of disolving ammoniacal gas in a similar way to alcohol. It has, further, this advantage, that it is low in price, and that the portion which

must, from its volatility, pass away with the gas, serves as an enricher or improver of the illuminating power.

I have here a test tube, such as is used for testing the condensation by bromine, the bulb of which I will fill with the gas supplied to the room. I will now add a little sulphide of carbon, and shake or mingle the gas and it together. The vapors of the sulphide of carbon are thereby diffused through the gas, and you observe that on removing my finger the water is considerably depressed in the tube, due to the increase in volume from the diffusion of carbon vapors. I will now add a little of this volatile fluid recovered from the waste shale gases, and shake the whole together, thereby bringing the sulphide of carbon vapor into contact with the fluid. On removing my finger under water, you see that it immediately rushes into the tube, and the gas assumes nearly its original volume. I say nearly, for the volatile fluid itself has given off some vapor, but the difference is solely due to the vapor of the hydrocarbon fluid, and not to the sulphide of carbon remaining; but that the vapors of the latter are entirely absorbed is proved by filling the bulb of this second tube, which is similar to the first, with the same gas, when you see that on adding the volatile fluid from the waste shale gases and shaking as before both have the same volume. This vapor, however, as I have already indicated, would not be lost, but would have this effect—that the illuminating power of the gas would be increased at a smaller cost than from any other source; and were it desirable to employ such a hydrocarbon fluid as would not, or only appreciably, volatilize into the gas, such a hydrocarbon can be easily obtained, and at a very low price.

We see, then, that this fluid has the power of dissolving sulphide of carbon vapors. Let us now see how it behaves with ammoniacal gas.

I have here a strong solution of ammoniacal gas in water. I will pour over it a quantity of the fluid hydrocarbon and shake the two together. The water and fluid, not being mixable with each other, separate at once in standing. I will now decant a portion of the hydrocarbon fluid, and pass it through the filter paper to free it from any mechanically suspended matters.

Now, you all know the affinity of water for ammonia, and yet you see that this hydrocarbon fluid has been able to deprive the water of a portion of its ammonia, notwithstanding its affinity for that substance; for it alone gives evidence of the presence of ammonia on this tumeric paper by changing it brown, and this red solution of litmus blue. I have here also a dilute solution of sulphuric acid, of such strength as is used for testing alkalies. I will add some of it to the ammoniacal fluid. You will observe that it takes some considerable quantity of the acid solution to neutralize it and change the litmus again red.

The quantity of the ammoniacal gas which this fluid can dissolve from such an aqueous solution of ammonia I have found to be about twice its own volume.

We have, therefore, in this ammoniacal hydrocarbon fluid a substance which would both readily dissolve the sulphide of carbon in the gas, and also combine with it.

With reference to the mode in which such a hydrocarbon solution of ammonia might be applied, I need scarcely make mention of them, as there are such a number of ways which will suggest themselves to you—such as using one of the ordinary scrubbers through which to pass the solution, or the solution might be used in the ordinary wash-vessel, when such would be available; but in practice I am of opinion that it would be best applied after the gas had undergone purification from carbonic acid, as the gas would combine with the ammonia to form the oxycarbonate, to the exclusion of the sulphide of carbon. The separation of the sulphocarbonate of ammonia found in the solution of hydrocarbon fluid can be readily effected by simply bringing it into contact with water, which would dissolve it out; and, as the fluid is much lighter than water, it rises to the surface and can be easily decanted, to be again saturated with ammoniacal gas to be re-employed for further treating the gas.

As you are aware, the affinity of simple hydrated alkalies for sulphide of carbon is not nearly so great as for the alkalies after being united with sulphuretted hydrogen to form hydrosulphide of the alkalies. Now it so happens that this fluid also freely dissolves hydrosulphuric acid. I have here a portion of the fluid saturated with that gas. You see that on commingling it with the salt of lead in this test tube the black sulphide of the metal is at once formed, and in great abundance. I will now mingle the ammoniacal solution with the hydrosulphide solution, when there is at once a combination between the alkalies and the acid gases in solution. You observe that there is no evolution of gas, but that both gases, although combining to form a salt, remain in solution. Therefore we have here the hydrocarbon holding in solution hydrosulphide of ammonia, which acts more energetically upon the sulphide of carbon vapor present in coal gas.

The hydrosulphide of the alkalies and alkaline earths is not soluble in this hydrocarbon fluid recovered from the gas, and therefore we cannot form a solution with lime or soda as we can do with the ammoniacal gas; but chemistry teaches us that although it is an advantage, in all cases it is not necessary that the fluid employed for bringing about a union between a gas and a solid, or between a solution of a chemical and a gas, be a solvent for both. In a great majority of cases it is found more important that the fluid be such as to dissolve the gas and reduce it to the liquid state, as in this state it can readily combine with another liquid holding in solution the chemical substance with which it is desired to combine the gas, or the solid substance being melted with the solvent of the gas, it acts as the medium for reducing the gas into a liquid, and transferring it to the solid with which it may enter into combination and assume the solid form.

Now at present, as you know, hydrosulphate of lime is almost universally employed when the sulphur compounds are removed from the gas. It will be evident to you, therefore, that to wet the lime compound with the fluid would have the effect of bringing about a rapid union between the sulphur compounds and the lime salt, as the fluid would dissolve the sulphide of carbon present in the gas in the gaseous or vaporous form, and bringing it into such close contact with the hydrosulphate of lime that the chemical affinity would come into action, and the sulphide would combine with the lime salt to form the carbosulphide of calcium. The wetting of the hydrosulphide of lime could be accomplished by spraying the fluid through the gas as it enters the purifier by a jet of compressed gas, or the fluid might be sprinkled over the hydrosulphide of lime by a pipe passing through the purifier cover.

Should it be desired to employ the hydrosulphide of soda in place of lime, then, that salt being soluble in water, it could be used as a watering solution combined or mingled with the hydrocarbon fluid, and the whole pumped through an ordinary scrubber, when the hydrosulphide of soda got saturated with sulphide of carbon it could be separated from the fluid, and the sulphide of carbon recovered by adding a strong acid to the soda salt.

But gas contains many other substances having sulphur in their composition besides sulphide of carbon, and which the hydrosulphide of the alkalies does not remove, but which this hydrocarbon removes readily. This fact has been observed long ago; for when a hydrocarbon fluid was employed for carburetting the gas used in the street lamps of London, it was obsered that however pure the fluid hydrocarbon might be from sulphur compounds, when put into the lamp to be carburetted, there was always left a dark residue having a most abominable smell, and which, when distilled, gave evidence by lead paper that it contained sulphur in its constitution. And you have all seen the hydrocarbon fluid which collects in drip boxes and on the surface of the water in the tank, which, as you know, has a most offensive smell, and which contains sulphur in its constitution.

Just as we at present employ water to absorb ammonia from our gas, so we might also employ this, or a similar hydrocarbon fluid, for the absorption of those sulphur compounds which escape other modes of purification. So soon as the fluid approaches saturation with sulphur compounds, it would become necessary to treat them for their elimination either by fractionally distilling them and removing the portion containing the sulphur compounds, or by simply distilling and treating the distillate with suitable chemicals (acid and alkalies), or by distilling them and subjecting them to the vapor of water or hydrogen gas at such a temperature as would bring about their decomposition, which would, to all intents and purposes, be a modification of the second set of processes referred to in the early part of this paper, and which would be practicable from the small quantity of vapor requiring treatment compared with the gas from which the sulphur compounds were derived.

All the hydrocarbons, such as those distilled from wood, tar, crude or palm pith, bitumen, and coal tar, have the property of absorbing those sulphur compounds; but there are none of them possessing so many necessary characters as this fluid or analogous fluids derived from petroleum. First and primarily, these are lower in price—the present cost being 3½d. or 4d. per gallon; secondly, they are largely composed of paraffin and other hydrocarbons which are not themselves acted upon readily by such chemicals as might be employed for the elimination of the sulphur compounds; and thirdly, they can be had in large quantities.

However, should this mode of purification be practically adopted, and any difficulty experienced in obtaining a supply of hydrocarbon fluid, the naphthas distilled from the tar could be easily employed, thus affording another proof that in the crude gas itself we have present all the materials necessary for its complete purification. Thus we have the tar to remove sooty matters, and when properly applied the water would remove every trace of ammonia, the ammonia all carbonic acid and sulphuretted hydrogen, and the naphthas the other sulphur compounds—thus providing a gas which would, so far as the noxious products of combustion are concerned, be as unobjectionable as the electric light.

Mr. Hislop (Paisley)—I have listened with the utmost pleasure to the paper we have heard read by Mr. Young. All the members of this

Association, as well as myself, are, I am sure, always satisfied when they see Mr. Young's name on the programme, for we are sure that we shall have a treat. To-day we have not been disappointed in this respect. The subject which he has so ably handled is one of great interest indeed—more so to our friends across the border than to us in Scotland, where we are not so much troubled with the bisulphide of carbon—but at the same time I think his paper is a very valuable contribution to the science of gas manufacture, and I am sure we all feel very greatly indebted to him for it. No doubt the commercial value of the agent by which the process of removing the bisulphide of carbon is to be performed will vary at different times, and it will be a matter for those who are more immediately in it to consider whether it is not worth their while to go to the cost of this material with the object of removing this much complained of impurity. I move a hearty vote of thanks to Mr. Young for his paper.

Mr. M'Gilchrist—I would also thank Mr. Young for his excellent paper; but there is a question or two which I would like to ask before the subject is passed over. I do not see that Mr. Young has clearly brought out certain points in reference to the use of this volatile hydrocarbon. For, seeing that the hydrocarbon fluid and the bisulphide of carbon are volatile, would not they both volatilize and pass away with the gas together? And, again, would not this hydrocarbon fluid have an affinity for the hydrocarbons that are in the coal gas, and take them down in the form of liquid along with the bisulphide of carbon, rather than to allow them to get away in a gaseous state? These are questions which I would like Mr. Young to answer, seeing that on the occasion of one of our meetings, some two or three years ago, he showed by experiment that the heavy hydrocarbons took down the light hydrocarbons. It seems to me that they would have the same effect here. Either Mr. Young was wrong when he spoke before, or he is wrong now. The two statements seem to me to be contradictory.

Mr. Aitken (Falkirk)—I have to say that this question of the purification of the bisulphide of carbon occupied my attention last year, and I made a great number of experiments, all tending in the same direction as Mr. Young has shown to-day, but these were interrupted during the fall of last year with sulphur in another quarter—(laughter)—and I have not been able to get anything done to it since. I cannot say that my experiments were quite as successful as Mr. Young's have been. One thing I was very clear about, that lime did not take out the bisulphide to the extent that is supposed by our friends on the other side of the border. Indeed, if it does so it is only to a very limited extent. One of the points that I really wanted to work out further in the same direction was not to bring in anything from an outside oilworks to accomplish the purification, but to manage to do all the work inside—to make the means of purification on the premises. It was at this point that I was interrupted.

Mr. Young—Mr. M'Gilchrist has asked two questions. First, he says, seeing that both the hydrocarbon fluid and the bisulphide of carbon are volatile, and that the sulphide of carbon present in coal gas is in the vaporous or gaseous state, would the volatile hydrocarbon remove it? And if it were absorbed or removed by the fluid, would it not have a tendency to revolatilize into the gas along with the hydrocarbon fluid?

I do not think so—at least, not if proper precautions are taken in the application of the fluid, and the danger referred to could only occur when the fluid was employed as a simple absorbent, and without the simultaneous application of chemicals.

For instance, the ammonia present in coal gas is, as you are aware, the vapor of a very volatile fluid, only condensing to a liquid at a temperature of 40° or 50° below zero, and yet we can remove every trace of that compound from our gas by the judicious application of water, and the volatile fluid boiling at 212° Faht.

Of course, we know that in order to free our gas from ammonia, care must be taken as to the manner in which the water is applied—that is, that it be employed in a succession of scrubbers, or in one very tall one, the pure water being made to act upon the nearly pure gas in the last or upper portion of the scrubber, and the partially fouled water employed to remove the ammonia from the gas as it enters the scrubbers. No doubt were we to bring the fouled water as it leaves the scrubbers into contact with the pure gas as it leaves the same, the ammonia would revolatilize into and again contaminate the gas; or if the water employed to absorb the ammonia were allowed to rise in temperarure, it would either not so perfectly remove the ammonia, or the ammonia which it had previously absorbed would be revolatilized.

In a similar way it would be necessary, in applying this hydrocarbon fluid for the removal of the sulphur compounds, to employ it in such a manner as to bring the pure fluid into contact with the nearly pure gas, and the partially fouled fluid into contact with the crude gas; and it would be further necessary, as far as possible, to guard against sudden changes of temperature, for this would not only cause difference in the rate of absorption of the sulphur compounds, but would also bring about differences in the illuminating power of the gas, due to the variations in the amount of vapor of the fluid diffused through the gas.

As I have shown you to-day, however, this fluid can be employed not only as a mere absorbent of the sulphur compounds from coal gas, just as water is employed for the removal of ammonia, but it can also be employed as the medium of bringing the sulphur compounds and the chemicals having an affinity for these compounds into such intimate contact as to cause them to unite, which would prevent all possibility of revolatilization into the gas.

Then, in regard to Mr. M'Gilchrist's second question, will not the fluid not only remove sulphur compounds, but also lead to the condensation of the hydrocarbons usually diffused through coal gas? Paradoxical though it may appear, there is no doubt that this fluid at first both absorps hydrocarbon and sulphur compounds from the gas, but at the same time it gives up to the gas a portion of its own vapor, for the same cause which leads to the absorption of the sulphur compounds, which are soluble in, but different in structure from, the hydrocarbons contained in the liquid.

At one of our Association meeting, I think at Musselburgh, I drew attention to the fact that a spirit or hydrocarbon fluid of a certain specific gravity had this effect when brought into contact with illuminating gas—that at low temperatures it lowered the illuminating power; and that on the other hand, at high temperatures, it increased the illuminating power. But in reality, when first brought into contact with the gas, in both cases it absorbs hydrocarbon therefrom, only that at low temperature it absorbed more of the hydrocarbon vapors usually present in coal gas than it gives up of its own vapors, thus causing a reduction of the illuminating power. At high temperatures, on the other hand, the reverse was the case, more vapor of the fluid being volatilized than was absorbed. This, however, takes place only for a short time, for the pressure of the large quantity of hydrocarbons soon brings about a balance of the vapor tensions of the hydracarbons, both of those usually present in coal gas and of the fluid hydrocarbon employed; but the sulphur compounds, being present only in infinitesimal quanties, this balance of affinities would not be brought about until the hydrocarbon fluid was nearly all volatilized, and it would therefore continue to absorb sulphur compounds long after it had ceased to have any effect on the hydrocarbon present in the gas, and such hydrocarbons as would be absorbed from the gas would be all rediffused through it, after the sulphur compounds had been separated either by distillation or by chemical treatment, or they could be otherwise utilized as solvents for other purposes. When at some of our other meetings I referred to the removal of the hydrocarbon compounds from coal gas, and the consequent reduction of the illuminating power, I showed that the heavy or dead oils are the hydrocarbon fluids possessing this power in the highest degree, and that the tars or other denser oils, which had so acted upon the gas and deteriorated its illuminating power were removed direct to the tar well, without any opportunity being afforded for the volitilization back into the gas of the absorbed hydrocarbons. In short, I showed that a volatile hydrocarbon fluid was diffused as vapor through a gas when brought into contact with it; but that when a denser or less volatile fluid was employed, the hydrocarbons were absorbed or removed from the gas.

Then, in reference to the remarks made by Mr. Aitken anent the action of the hydrosulphide of lime upon the sulphide of carbon, there can be no doubt whatever about the chemical fact that on bringing the vapors of sulphide of carbon into contact with hydrosulphide of lime, a union takes place; but perhaps the lime employed by Mr. Aitken in his experiments had been wet, which, as Dr. Odling in the quotation I have read to-day shows, retards or prevents the union of the sulphide of carbon with the lime compound. But if the hydrosulphide of lime had been wetted with this fluid instead of with water, he would have found that the sulphide of carbon would nave been removed and combined with the lime salt, to form the sulphocarbonate of lime.

In the Clippens works we remove nearly all the illuminating power from our waste shale gases by dissolving out the vapor with heavy oil, in the manner which I have had the pleasure of describing to you at our previous meeting. We, however, require a portion of the gas for illuminating the works and for use in the laboratory, and in order to fit it for such purposes it is necessary that the sulphur compounds be removed from it by the ordinary process of purification, and that illuminating power be conferred upon it by diffusing through it a portion of the vapors of the hydrocarbons previously removed by the heavy oil.

A very convenient means of carburetting the gas was found to be by pouring through the plug of the purifier a portion of this fluid upon the purifying material. Upon removing this purifying material after having been thus treated with the fluid, we found that it contained many other sulphur compounds than sulphuretted hydrogen, possessing a most abominable smell—so much so, indeed, that the men would rather come in contact with anything in the works than the purifying material when containing the abominable-smelling sulphur compounds. Some years ago the idea

suggested itself to me of increasing the efficiency of the ammonia refrigerating machine by employing the ammoniacal gas after leaving the expander in the refrigerating chamber, and on its passage to be absorbed by water, in order to bring about a further amount of cold by passing through a vessel filled with a very volatile portion of this fluid. By this means I expected that the fluid would be diffused through the ammoniacal gas, and that when that gas was condensed by absorption with water, the volatile fluid would also be condensed, or that, in other words, the tension of both would be simultaneously reduced, and so bring about their liquefication. I was supprised, however, to find that, instead of cold being at first produced in the passage of the ammonia through the liquid, there was evolved a considerable amount of sensible heat, this being due to the absorption of the ammoniacal gas by the hydrocarbon fluid; and thus I observed that this fluid had the power of dissolving ammoniacal gas.

Last year, when Mr. Aitken was experimenting upon the removal of sulphide of carbon by means of the tars, he and I had frequent conversations on the subject; and I believe that those conversations, along with the other suggestions which I have just enumerated, together with the reading of Dr. Odling's lecture and the difficulty of finding a market for this product, led me to give the matter closer attention; and although, of course, the process has not yet had any practical application, I have thought it advisable to bring the subject before you, for I am of opinion that it is most desirable that all such matters should be brought under the consideration of such associations as this as early as possible, for thereby many minds are brought to bear upon it, and, if there is anything in it, it makes much more speedy progress to perfection than would be possible when confined to one mind, and thus lead to the ultimate good of every one.

A hearty vote of thanks was accorded to Mr. Young for his valuable paper.

[From London "Journal of Gas Lighting."]

The Proposed Substitute for Candles in Testings for Illuminating Power.

"Mr. A. Vernon Harcourt has written to the Board of Trade a letter which has the appearance of being a private communication, but which has been made a public document by being printed and circulated by the Board. We scarcely understand the position of his colleagues in regard to this matter. There are three Referees, whose salaries are paid by the gas companies; two of these gentlemen, the Acts of Parliament say, shall form a quorum, and concur in any recommendation and instruction. In the document above referred to, however, which we are bound to regard as of some importance, the names of Mr. Harcourt's colleagues do not appear. We are obliged, then, to regard it as a private communication. Mr. Harcourt is very much dissatisfied with the candle test, and therefore is anxious to substitute another which he considers more reliable and trustworthy. "I desire," he says, "to obtain the sanction of the Board of Trade to the introduction at the testing-places" established for testing gas supplied by the Metropolitan gas companies "of a more trustworthy standard." We may stop here for a moment to express a strong opinion that the Board of Trade have no power to change the standard of comparison. The Acts of Parliament say that the gas supplied shall have an illuminating power of *sixteen candles*. The Referees have the power to prescribe the apparatus to be used in ascertaining the illuminating value, and at that point their obligation ends. Candles are the universal standard, which can only be changed by some general enactment. We are far from saying that the use of candles gives entirely satisfactory results; but as no approach to scientific precision is possible, even with Mr. Harcourt's pentane test, we may be excused for expressing our adhesion to the old standard. And on this point we may call Mr. Harcourt himself to witness. He admits that taking the mean of three testings during the day tends to neutralize the variations of the candles; and, further, he says that, according to his experience, "it does not often happen that any one of a set of three testings varies by more than half a candle from the mean of the three. This is the case even if a different pair of candles is used for each testing, when the candles are from the same packet, and the mode of operating is kept rigorously uniform." Further than this, he admits, "that when candle testings are made with great uniformity, fairly concordant results may be obtained." Beyond this, in an appendix, he shows that when tests are made alternately with pentane and candles, the variations in the latter are really but small.

It may be asked, can we be more certain of the invariability of the pentane test, any more than that of candles? We may take it that it would be a difficult matter to answer this question. Pentane, as prepared by Mr. Harcourt himself, is a body of definite composition and great volatility; but who is to guarantee that all poured into the holder is volatilized and diffused through the bulk of air contained therein? We admit that the presumption is, of course, in favor of the perfect diffusion of the whole of the pentane vapor in the air. Still, we do not see how this is to be guaranteed; and when a second portion of pentane is poured into the holder, we deem it possible that it may meet with some residual unvolatilized pentane, and so the light of the flame may be a little enhanced. We do not put this as an objection to the pentane test; all we would say is, that the objections which appertain to candles will apply with equal force to the hydrocarbon test, which is really a candle test in disguise. Doubtless, as stated by Mr. Harcourt, the testing of gas by candles is affected by causes, the influence of which the actual application of the method of average does not tend to eliminate. Different operators, we know, have different modes of proceeding. Some, as Mr. Harcourt says, turn down the tips of the candles; others trim the wicks. In this latter case, we hope they leave them burning for some considerable time before they begin testing, otherwise great differences are sure to be observed. Uniformity of usage with candles cannot be too rigidly enforced on gas testers; and if that be followed, as Mr. Harcourt says, "fairly concordant" results may be obtained.

It only remains to be noticed that the writer of this letter does not ask to have the system adopted on his own responsibility. He wishes to have it examined into and reported upon by a body of experienced gas examiners, who will inform the Board of Trade of the results of their examination and inquiry. Such a Committee, we believe, has been appointed, and we shall presently know the results they have arrived at.

The following is the letter by Mr. A. G. Vernon Harcourt, one of the Metropolitan Gas Referees, to the Assistant Secretary of the Board of Trade—

Sir:—I desire to call the attention of the Board of Trade to the untrustworthiness of the standard which is at present in use for estimating the illuminating power of coal gas.

I desire to obtain the sanction of the Board of Trade to the introduction at the testing places established for testing gas supplied by the Gaslight and Coke Company, the South Metropolitan Gas Company, and the Commercial Gas Company, of a more trustworthy standard.

Under the Acts of the above-named companies, the Gas Referees are charged with the duty of prescribing the materials and apparatus to be used within the testing-places for testing the illuminating power of gas. Soon after my appointment, in 1872, as one of the Gas Referees, in the course of experiments upon the effect of heating gas, with a view to its purification from sulphur, the inaccuracy of the usual photometric process was brought under my notice. In 1874 I began a series of experiments with the aim of devising a more trustworthy process, which I have continued with occasional intermission till the present time.

In the course of my experiments I have had occasion to make a large number of testings with candles of the kind ordinarily employed, and also with candles differing in diameter and in the structure or preparation of their wick, but coming within the definition of "sperm candles of six to the pound, consuming 120 grains of sperm per hour."

For some account of the results of these experiments, I may be permitted to refer to a paper "On a New Unit of Light," read before the Chemical and Physical Sections of the British Association, at its meeting in Plymouth in 1877, a copy of which accompanies this letter.

The existing system of photometry attempts to neutralize the variations in the amount of light emitted by standard candles by using two candles simultaneously, and by extending each testing over a period of ten minutes. The further provision that three testings shall be made daily, and that the mean result of the three shall be taken to represent the illuminating power for the day, though intended to provide for fluctuations in the quality of the gas supplied at different hours, really serves also to neutralize the variations of the standard candles.

This method of obtaining a fairly accurate result by taking the mean of a number of experimental results varying considerably one from another is rightly used, and leads to correct conclusions, when the experimental errors are likely to be evenly distributed, and when the whole series of observations is not liable to be affected by a common cause.

Thus, if a single candle were employed to yield a standard light, and if the correspondence between its light and that of a gas-flame were observed during one or two minutes, the variations in the results obtained by the same operator using the same candle in the same photometer would be very great. In the actual mode of working, the variations are not very great. According to my experience, it does not often happen that any one of a set of three testings varies by more than half a candle from the mean of the three. This is the case, even if a different pair of candles is used for each testing, when the candles are from the same packet, and the mode of operating is kept rigorously uniform.

In Appendix I., I have put together the results of a large number of candle-testings made in my laboratory with the view of obtaining a receipt for preparing a gas from hydrogen and pentane, which should have, when consumed by a standard burner, exactly the illuminating power of 16 candles.*

* Important as are the appendices which accompany this letter, space will not admit of their being given in the *Journal;* they occupy 19 pages of printed foolscap, and consist largely of tabular matter.

Such a gas might be used as a photometric standard in the manner which I described and showed in a lecture before the Society of Arts on the 31st of March, 1876.

Three testings were made of each sample of gas, stored in a small gas-holder, in quick succession, one after the other, so that the light given by the gas did not vary, and the variation between the three results is due solely to errors of observation, which are inconsiderable, and to differences in the illuminating power of three different pairs of candles treated similarly in every respect. The numbers have been corrected, as usual, on the assumption that the light given by similar sperm candles varies directly with the weight of spermaceti consumed; and where the consumption of gas was in any degree greater or less than 5 cubic feet an hour, a proportional correction has been introduced.

The conclusion which may be drawn from this large number of observations is, I think, that when candle testings are made with great uniformity, fairly concordant results may be obtained. It is, no doubt, owing to the fact that concordance is attainable under these conditions that an amount of confidence is bestowed upon candle testings to which they are not really entitled. In fact, the greater pains an operator takes to obtain concordant results by working in a perfectly systematic and uniform manner, the less significant and trustworthy do his mean results become.

The result of testing by candles of any sample of gas depends upon many conditions beyond those named in the Companies Acts of Parliament and in the notification of the Gas Referees, and is effected by causes the influence of which the actual application of the method of averages does not tend to eliminate.

I will here paint out a few of these, in addition to those mentioned in the accompanying paper.

1. Since the prescription of the Gas Referees of the apparatus to be used in the Metropolitan testing places, which included a balance external to the photometer for weighing the candles used in testing, a new form of balance has been substituted by Mr. Keates, chemist to the Metropolitan Board of Works, by which the candles are weighed *in situ* within the photometer. The plan of weighing the candles *in situ*, or of observing, without moving or extinguishing the candles, the time required for the consumption of 40 grains of spermaceti, is both less troublesome and more accurate. Its introduction is therefore a boon to the Gas Examiners; but I believe that it is also a boon to the Gas Companies, since it is practically impossible to transfer a pair of lighted candles from a balance to the photometer without filling the cups of the candles with melted grease, and thus increasing the light of the candles, probably by diminishing temporarily the length of wick within the flame.

2. Some operators make a point of trimming the wicks of their candles; others of leaving them alone. I have known a difference of 2 candles to be made in the illuminating power attributed to a sample of gas, by simply bending down slightly the wicks of the candles between a first and second testing. A similar difference may be produced by cutting off the tip of the wick.

3. The greater or less movement of the air around the candles in an open photometer, and the greater or less movement of the candles to and fro in a box photometer, according to the habits of the operator, affect considerably the results of a testing, or set of testings. Perfect stillness is unfavorable to the development of the light of a candle, and this, I believe, is one reason why open photometers sometimes give results less favorable to the gas than box photometers.

4. The mode in which a candle has been extinguished, and the time during which it is allowed to burn before a testing is made, are also points of some importance, as to which the practice of different operators is different.

5. The age of the candles is said to make a difference in their burning. Mr. Heisch, who has had much experience in photometry, has told me that he finds it best to buy candles and keep them for some time before using them.

6. Candles with 18 threads in each strand of the wick generally burn less than 120 grains of spermaceti an hour, and candles with 21 threads generally burn more. After correcting for the excess or defect of consumption, the results obtained with the former candles are about half a candle less favorable to the gas than those obtained with the latter.

7. The candles which I have been accustomed to use, and I believe also those sent by Mr. Keates to the testing places, are made by Mr. Miller, of Dorset Wharf, Westminster. According to some recent experimeets, a summarry of which is given in Appendix IV., in which the same sample of gas has been tested both by Miller's candles and by those of another maker named Brecknell, the candles of the former maker give for the same consumption of spermaceti six or seven per cent. more light than those of the latter.

The above list might be extended by the enumeration of other details in which the practice of one Gas Examiner may differ from that of another with the result of producing a material difference in the illuminating power attributed to two precisely similar samples of gas.

I submit, therefore, that the standard now in use is not sufficiently definite and uniform to be maintained as a standard; and that it is desirable, if possible, to substitute for it a standard more definable in its nature, and less liable to be affected by the manner in which it is used.

In the paper "On a New Unit of Light," to which I have referred, a description is given of the standard which I propose as a substitute for the sperm candle. A more extended comparison of the illuminating power of this standard flame with that of various sperm candles has led me to make a slight alteration in the height of the flame, and in the proportion of pentane used in preparing the standard gas. The height of the flame burning from a ¼-inch aperture, which is most nearly equal to an average sperm candle flame, is 2½ inches. The volume of liquid pentane which is to be poured into three cubic feet of normal air is nine cubic inches, measured at 60° Fahr.

The photometric comparison of the sample of gas to be tested with this standard flame may be made as when candles are used. But I find it more convenient, and equally exact, to keep the disc at rest in the position corresponding to the normal illuminating power of the gas (*e. g.*, for 16 candle gas, four times as far from the gas as from the standard), and the standard flame also at rest. The observation is made by regulating the consumption of gas till the disc is equally illuminated on both sides, and then ascertaining by reading the meter once or twice, at intervals of one or two minutes, what the rate of consumption is.

In the system of gas-testing used in Paris, the return made is not of the illuminating power of the gas when burning at a particular rate, but of the volume of gas required to maintain a certain amount of light for a certain time.

I venture to think that this system is more exact and more reasonable than the system in use this country.

It is more exact because the same burner may be used with equal advantage to produce the light of (*e. g.*) 16 candles from different samples of gas burning at very different rates; but the same burner cannot be used with equal advantage to consume at a fixed rate of (*e. g.*) 5 cubic feet per hour samples of gas varying to anything like the same extent in their illuminating power.

It is also, I venture to think, more reasonable because the difference to the consumer of being supplied with a richer or poorer gas is measured, not by the illuminating power of the gas, but by the volume of gas which he requires to burn in order to obtain a fixed amount of light. For example, if on any evening the consumers in a London district were supplied with 14-candle gas instead of 16-candle gas, their houses would not be less well lighted than at other times, but they would use and would have to pay for about 10 per cent. more gas.

Considering, however, the difficulty of changing a custom and nomenclature established in popular usage and in Acts of Parliament, probably the change of system could only be effected indirectly; and the alteration I have suggested in the photometric process would indirectly effect this change, if in the calculation of the result it is assumed that the illuminating power of the gas burnt so as to yield a fixed amount of light varies inversely with the rate of consumption.

It is the case that this inverse relation exists with the standard burner for samples of gas varying from rather below 16 candles up to 17 candles illuminating power; and nearly all the gas tested at the Metropolitan testing places falls within these limits. Thus, for the orninary range of the testings of illuminating power made upon the gas supplied to the Metropolis, it is immaterial which system is employed. If the gas supplied falls considerably below the standard quality, the deficiency appears to be greater when the gas is consumed at a fixed rate and the light which it yields is determined than when the observation is of the rate of consumption requisite to yield a fixed amount of light. The cause of this is partly general, that comparing larger gas flames with smaller, the gain in illuminating power with the larger flame is more than in proportion to the increased consumption; in part it depends upon the particular burner employed, which is constructed for producing a flame giving a light of from 16 to 17 candles.

How rapidly with this burner the yield of light diminishes when the consumption is reduced, may be shown by making a great reduction, such as from 5 cubic feet per hour to 4 cubic feet. In this case the light is reduced from that of 16 to that of little more than 8 candles.

The numbers representing the illuminating power of gas estimated in the manner here proposed would truly represent the advantage to the consumer of the sample of gas supplied to him, as far, at least, as it is possible to infer from any testing with one burner chosen as a standard, with the effect of a change in the quality of gas is with other burners. A fall in the quality of the gas from 16-candle to 15-candle would represent an increase in the charge made to the consumer of 1-15th, or 6⅔ per cent. For the quality of the gas thus estimated, "illuminative value," is a better term than "illuminating power."

Before a change could be made in regard to the existing standard of photometry, it is necessary not only that a more trustworthy standard should have been devised, but also that the relation between the old and the new standard should have been ascertained as definitely as possible.

The more fluctuating and uncertain the existing standard is, the greater is the difficulty of ascertaining exactly this relation.

In Appendix II., I give a summary of experiments made in Oxford with the view of fixing the exact composition of the mixture of pentane and air, and the exact height of the flame produced by the burning of the mixture, which should be the representative of a standard candle flame, and also should furnish a convenient rate of consumption, such as half a cubic foot per hour.

In Appendix III. I give a summary of a small number of similar experiments made with a different form of photometer.

Appendix V. contains the results of a series of experiments, still in progress, made with a third photometer by Mr. Frank Livesey, at the works of the South Metropolitan Gas Company.

As I cannot expect, and do not wish, that the Board of Trade should sanction so considerable an innovation as the substitution of a new for an existing standard on the evidence supplied by one person, I venture to ask that an independent inquiry into the relative merits of the existing standard and of that which I have proposed may be instituted.

If the Board of Trade should be willing to appoint two or three scientific men to inquire and to report to them on this subject, I will gladly assist the inquiry in any way that is open to me.

(Signed) A. Vernon Harcourt.

[From the "Coal Trade Journal."]

Gas and Gas Making.

By L. P. Gratacap, Ph. B.

The average housholder, partly from tradition, partly by inherited prejudice, through personal grievances and misunderstandings, regards the gas company who supplies his dinner table, his parlors, and his bedrooms with light, as an exorbitant monopoly, commissioned to impose upon its consumers, and to be resisted in any way, as invention or shrewdness dictates. Gas is somehow classed with sunlight and air—a universal element, upon the use of which no restraints should be laid, and which belongs quite naturally to any one who can or cares to use it. When the announcement of Edison's discovery of a cheap and brilliant substitute was made, a perceptible thrill of exultation went through the community. Surely Edison has much to answer for if he wittingly deceived his admiring audience, and, after promising them emancipation from an unnatural yoke, and luring them into a distempered glee, now permits them to return to an odious bondage and a discarded nuisance.

Much, perhaps, of this ill-natured criticism of gas companies arises from an insufficient sense of the privileges gas bestows, its delightful assistance and protective influence; from ignorance of the amount of skill and invention that has been shown in the history of its improvement, and of the advanced state its manufacture has reached through persistent experiment. It is not to satisfy any profound craving after knowledge in gas making that we offer a general sketch of this industry, but rather to temper with a little reasonable information a surprising indifference as to what gas is or how it is made.

THE MATERIAL.

Not the least interesting topic connected with this subject is the material which yields the gas, and which, in whatever relation it is discussed, chemical, geological, or botanical, is one of the most remarkable objects offered to human study. It is coal. Those black, sightless heaps of grimy stone which fill the bins of our coal yards, represent the pivotal bearings of a nation's wealth. In other words, the heat that keeps winter from our door, the motion that carries us over hill and dale, the agency by which our ores are made to yield the sinews of commerce, and the cheerful flame that renews day in the night, all proceed from coal. The half-expressed apprehension of her statesmen that in 300 or 400 years England's supply of coal will become exhausted, and with its decline her naval and industrial supremacy disappear, strikingly illustrates the pre-eminent role King Coal may yet play in history. America views her own immense coal beds with complacency, and sees in them a sort of fore-installment of means ample enough to develop her enormous mineral resources and assist in the continuous growth of that of other peoples. The coal-bearing area of the United States, as compared with the available areas of other countries, is shown in the following table, quoted from Le Conte:

United States	120,000 square miles.
British America	18,000 "
Great Britain	12,000 "
Spain	4,000 "
France	2,000 square miles.
Germany	1,800 "
Belgium	518 "

But how directly related the industry of coal mining is to the growth and development of the nation, and how the tables of its production are in a way criteria of the country's condition, is seen from the adjoined valuable statement:

Countries.	Yield in 1855. Million tons.	Yield in 1875. Million tons.	Percentage Increase.
United States	5	50	900
Great Britain and Ireland	66	133	100
Germany	8	50	462
France	7.5	17	126
Belgium	8	15	88
Austria	2.5	12	380
Russia	.5	1.5	200
Australia	.25	1.5	500
Spain	.25	.75	200

This increase of 900 per cent. has been largely due to rapid and abnormal increase in population, to change from wood fires to coal fires (a cause which has similarly operated in Germany and Austria), and to an enlarged consumption of fuel in living, manufactures, and railroads.

What is coal? Thanks to a long series of minute investigations, we are able to answer this inquiry with considerable confidence. It was plants that contributed their parts, whether branches, leaves, twigs, bark, spores, or roots, to form extended layers of vegetable matter, which, collected after many seasons of decay and growth over immense flats, barely emerged from the waters of adjacent seas, or in swampy basins, built up seams of woody fibre that, through subsequent alteration, made our coal veins. Mr. Wunsch, of the Glasgow Geological Society, says that, from personal observation on the Isle of Arran, three or four inches of coal represents twenty generations of trees, and that in one foot of coal is condensed the vegetable debris of 18 centuries.

Four genera of plants were prominent among—indeed, almost solely composed—the vegetable life of that time, enjoying a wonderful vitality and vigor, contrasting strangely with the meager subsistence of their modern relatives. These plants were ferns, equisetæ or horse tails, sigillaria, and lepidodendra. The ferns, like the low-waving forms whose fronds adorn our rock gardens, and others, whose size resembled the tree-like proportions of the tropical species, mingled together in the woods. Great numbers of their fallen sprays and delicate leaflets are preserved on the floors and roofs of the coal seams, and impressions left over slabs of stone, formerly a plastic mud, which faithfully stereotyped every detail, acquaint us with the species that then flourished.

But much above these in importance, and more remarkable in appearance, were the lycopods, the lepidodendra, and the sigillaria. These plants were closely related to each other, and were identical in functions and general type of organization. The sigillaria, or seal tree, has contributed in large part its bark, branches, and especially its cellular core, which formed a pithy axis throughout its trunk and superior divisions, to the formation of the Nova Scotia coal, as revealed by the microscope to Dr. Dawson. He says, "These trees present tall, pillar-like trunks, often ribbed vertically with raised bands, and marked with rows of scars left by the fallen leaves. They are sometimes branchless, or divide at top into a few thick limbs, covered with long, rigid-like foliage."

The lepidodendra were larger, more striking, and more attractive plants. Their branches were more numerous, forked, and with slender leaves wound around them in continuous spirals. These at first clothed the trunk and limbs, but as the tree expanded and rose they shriveled from the older parts, leaving lozenge-shaped scars in a quincunx order, whose form has offered an artificial and useless indication of specific differences. Many species made according to this mistaken criterion are really parts of the same species, being frequently but outer or inner bark.

These trees, multiplying their awns by their peculiar style of division (dichotomy), waved a shower of their leaves and flexible branches through the air of the carboniferous day, rapidly absorbing the carbonic acid about them, which, decomposed by the sun, fed their increase. Noticeable among these leaves were the lepidostroba—cone-like bodies enveloped in imbricated sheathing scale—which contained the spores or seeds for new plants. When ripe their dispersion took place much as the winged seed of our pines filter out from the cones and shower in clouds upon the ground. These minute sacs of the lepidodendron, though only 1-20th of an inch in diameter, actually constituted the bulk of large deposits which, carbonized, now form some of the best English coal. Modern instances are not wanting affording some corroboration of this remorkable assertion.

In Invernesshire a shower of fir pollen occurred which hid the ground about for miles, and in places was half an inch thick. Immense palls, traveling with the wind, have hidden portions of the sky to observers in

Virginia and North Carolina, which proved after investigation to be clouds of pine seeds. A more interesting parallel is found in the tasmannite of Australia. This is a shale, six to seven feet thick and miles in extent, highly resinous and burning readily. The microscope shows the presence of numerous spores, sacs, and their accumulation in these shists has rendered the beds bituminous and combustible.

The last important member of this carboniferous flora was the calamities or equisetæ. These were rush-like canes, growing very high, bearing whorls of leaves at regular intervals, and tapering to a narrow and acute summit, tufted with crowded clusters of small leaves. They are related to the scouring rush, whose sillicious stipes makes a cheap sapolio for the rural housewife. They grew in hedges along the margins of low levels, and arrested the invasion of drift and sand over the interior country where the sigillarias and lepidodendra were storing up in comparative purity the fuel of the future. These plants collectively have furnished a great part of the material for our coal, their contributions far preponderating over the slight additions furnished by pines and cycads.

Their luxuriant vegetation was grouped in swampy and extended basins, low throughs, and estuarine flats, scarcely elevated above or insecurely separated from the sea, and subject to occasional incursions of the latter, which hid, at each successive overflow, the new accumulations, and sealed them up in recurrent strata. They heaped up mouldering and rotting trunks, leaves, branches, and spores, which afterward were compressed by a weight of sand and mud, consolidated by heat, and metamorphosed by the alembic power of chemical forces, Thus was prepared, from the sodden, rank, and fermenting layers the hard and soft coals which fill our coal scuttles, blaze on our hearths, and feed, by tons, the fury of our furnaces.

Along with these towering club moses, and, probably, composing a ground tier from which they rose, enormous stretches and mitres of peat bog were engaged, century by century, in preparing deposits of vegetable fiber many hundred feet deep. Lesquereux says, "In ancient peat bogs, the peat, especially near the bottom, becomes black, compact, intermixed with layers of crystalline, though still soft, coaly matter, which only wants hardness to be comparable to true coal, or even undistinguished from it." The essential importance of peat in coal making may be judged from its present utility in supplying a primitive fuel and its local extent. It is used as a substitute for coal in Ireland, Germany, Switzerland. America, and Sweden, and in Indiana covers one area three miles wide, sixty miles long, and varies from five feet to fifty feet in thickness.

It does not seem necessary to presuppose an atmosphere essentially diverse from our own, though it was once thought that carbonic acid, the food of plants, should have far exceeded its present proportions in the carboniferous age, to provide for the enormous appropriation of it by the rank vegetation. Yet, although there are but three to four parts of carbonic acid at present in 10,000 parts of air, there still rest over each square mile of the earth's surface 1,300,000 tons of this gas, containing 371,475 tons of carbon, and but the slightest increment would raise these figures astonishingly. Surely here is reason enough to warrant our rejecting the prevalent conception of the necessity of a noxious atmosphere, crowded with this irrespirable gas, in the days of the coal measures. Moisture, however, abounded, the air was heavy with humidity, frequent and long rains watered the luxurious forests, and hot fogs enveloped at times the highest trees. The climate was equable, and since we do not find in the remains of exogenous trees any rings of growth, it is concluded that growth was continuous, and not annually interrupted by cold winters.

The thickness of the coal seams varies from thin films to strata forty feet in thickness, though, in most instances, impure beds lessen the workable veins of coal by many feet. These coal beds extended over wide areas, embracing thousands of square miles, they vary throughout their extent in thickness—the same seam thinning out almost entirely and thickening again to its greatest depth—illustrating the varying surface of the land, its depressions, its margins and drier parts. and the contrasted luxuriance and poverty of the vegetattion.

The formation of coal from woody tissue can be chemically expressed with sufficient clearness to allow us at least to apprehend the stages of the process and the nature of the bodies whose disappearance from the original fibre leaves the carbonaceous residue known as coal. Wood is composed in its ultimate analysis of carbon, hydrogen, oxygen, nitrogen, sulphur, and other mineral constituents taken up by the plant from the soil. These elements are grouped in a form obscurely, if at all, understood, and the multiplex reorganization of these compounds in decomposition and slow burning up. which that implies, results in eliminating certain products of hydrogen, oxygen, and carbon, whose aggregate effect is to increase the carbon in the parts remaining. The abstraction of carbon, hydrogen, and oxygen takes place under the form of water, carbonic acid, carbonic oxide, marsh gas, rich oils, which are for the most part collections of a vast variety of bodies made up of carbon and hydrogen combined in different proportions. The transition, then, of a wood to coal embraces a series of states, and could we arrest action at various successive points we would discover the general tendency of the changes taking place, and probably, also, meet with a number of substances specifically distinct. In a rude way nature has done this for us, and we can arrange in a line a number of natural products, each of which represents a certain broad comparatively permanent phase in the process, and conducts us from the raw material, wood, to the perfect product, anthracite or graphite. Such a scale would read, with its table of component parts, as follows:

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Ash.
Wood	49.70	6.06	41.30	1.05	1.80
Peat	58.18	5.96	31.21	1.23	3.43
Lignite	67.09	5.55	20.35	2	4
Bituminous coal	75	5	13	1	6
Semi-bituminous coal	—	—	—	—	—
Semi-anthracite	—	—	—	—	—
Anthracite	92	2	2	2	2
Graphite	100				

Of course it must be understood that the above percentages of comparison are varied in every particular instance where a specific coal is examined, since the age of the coal, any particular circumstance of its formation, the plants or parts of plants that composed it, some modifications of the process of alteration, one or all produce corresponding variations in the result, so that the above table represents the most general average from numerous analyses, and corresponds strictly with no single result. Yet the briefest inspection shows two things: first, a concentration and increase of carbon; second, a gradual disappearance of hydrogen and oxygen. To bring this latter fact into greater prominence, Prof. Thorpe has constructed a table where, by making the carbon constant, the removal of the hydrogen especially, and that of the oxygen also, gain an exaggerated effect.

	Weight of one solid cubic foot in pounds.	Carbon.	Hydrogen.	Oxygen and Nitrogen.
Wood	30	100	12.3	86.8
Peat	50	100	9.7	54.7
Lignite	70	100	8.3	40.
Brown coal	75	100	7.4	29.7
Bituminous coal	80	100	6.4	13.4
Anthracite	90	100	2.6	2.3

A closer examination of these substances will disclose a number of interesting facts.

The initial stage of the change of this vegitation into coal began with a complete or partial maceration and rotting of the woody tissue, accompanied or followed by a fermentation interfered with and impeded by pressure and protection from air. The albuminoid constituents of the wood start this putrefactive process, during which oxygen is absorbed and water and carbonic acid eliminated, while a rise in temperature indicates the combustive nature of the action. A stage must have been soon reached, which probably approached the state of things existent in vegetable mould, when the dark mouldy body, known as *humus*, is produced by decomposition, forming on the surface of ground a rich and efficient manure, and representing an intermediate step in the production of coal. Thus, the following table from Prof. Thorpe shows ah increase of carbon and a removal of hydrogen and oxygen:

	Carbon.	Hydrogen.	Oxygen and Nitrogen.
Woody tissue	50.2	6.2	43.6
Oak humus	54	5.1	40.9
" "	56	4.9	39.1
" "	55	4.8	39.9
Moss "	54	4.6	41.4
Average	54.8	4.8	40.4

It was due to this softening. which doubtless greatly varied in different places, and left the evidence of such local differences in the physical structure of the coals produced, that we find the trunks of sigillaria, ferns, and lepidodendra flattened whenever they were exposed to pressure, and their cellular cores squeezed out. Those trunks which preserve their rotundity are found in the middle of the coal veins, where the yielding and pasty mass found a cushion against external pressure.

The disintegration thus begun continues with precisely similar effects, concentrating carbon, and proportionately discharging hydrogen and oxegen until peat-like bodies form. Peat bogs themselves show, in their vertical sections, the gradual gradations from the unchanged vegetable matter on the surface to dense and coaly layers on the bottom, where organic texture seems obliterated and a real coal encountered on the very verge of its actua production.

PEAT ANALYSES.

	Carbon.	Hydrogen.	Oxygen.	Nitrogen.	Ash.
Philipstown, Ireland.....	57.52	6.83	32.23	1.42	1.99
Wood of Allen.....	58.30	6.43	31.36	1.22	2.74
Upper Shannon.....	58.53	5.73	32.32	.93	2.47
" " dense	59.42	5.49	30.50	1.64	2.97
Average.....	58.18	5.96	31.21	1.23	3.43

It must be remembered that where the vegetable debris undergoes a stifled combustion, the products become more complicated, and, as under water, a release of both carbon and hydrogen takes place simultaneously in the form of marsh gas or carburetted hydrogen, the fire-damp of mines, against whose frightful aptitude to explosion the safety lamp of Sir Humphrey Davy and Ansell's indicator are both well-known protections. It seems likely that the transition of peat coals to ordinary bituminous coals might have been effected by pressure; some slight degree of heat, and the continuous consolidation of fixed carbon and the formation of higher and higher homologues of marsh gas and olefiant gas, which, if not effectually existent in the coal, instantly group themselves out of more elaborate mixtures upon the application of heat.

The stage of lignite chemically succeeds that of peat, though it appears questionable whether all coals passed through its physical aspects.

Lignite is fossilized wood, light or dark brown in color, of a woody texture, yielding vinegar or ascetic acid upon dry distillation, friable and brittle.

ANALYSES OF LIGNITE.

	Carbon.	Hydrogen.	Oxygen and Nitrogen.
Devonshire.....	67.9	5.8	26.3
Cologne.....	67	5.3	27.7
Washington Territory.....	69	7	24

Brown coal is an advanced state of lignite, wherein organic structure disappears and ammonia results from distillation.

ANALYSES OF BROWN COAL.

	Carbon.	Hydrogen.	Oxygen and Nitrogen.
Tasmania.....	71.9	5.6	22.5
Auckland.....	72.2	5.4	22.4
Hungary.....	72.5	5.4	22.1

The bituminous coals forming the next substantial group, next to the brown, so far as chemical composition is concerned, are those rich coals, burning with a smooky flame, possessing a resinous lustre, yielding large quantities of volatile products, and having a fracture more or less conchoidal. They vary greatly in composition, for they occupy that broad and intermediate position between lignites or peats and anthracites, wherein are found the progressional states of carbonization and molecular change from bodies with 50 per cent. of volatile matter, to others with less than 4. The elaborate structure of wood or cellulose, with which we started, has been profoundly disturbed, a wonderful reduction and a rearrangement of atoms have taken place, accompanied with the potential birth of a great number of bodies ready to escape in the form of vapors, tar, and gases upon the application of heat.

The variability of composition in this class of coal is readily seen by a comparison of the subjoined analyses, selected from Barr's "Combustion of Coal."

	Mecklenburg Co., Ky.	Blossburg, Pa.
Fixed carbon.....	51	73.11
Gas.....	42.50	15.27
Water.....	2	
Ash.....	4.50	14.98
	Clay Co., Ind.	Cumberland, Md.
Fixed carbon.....	44	68.44
Gas.....	47.50	17.28
Water.....	4	
Ash.....	4.50	13.98

The examples from Kentucky and Indiana represent bituminous coals in the professional use of that term, while those from Pennsylvania and Maryland illustrate the average composition of semi-bituminous coals, though necessarily the distinction admits of no specific definition, as we can pass from one to the other through a scale of carefully graded states of carbonization. The behavior of this class of coals under the influence of heat assumes two very different aspects, and has, consequently, afforded a more or less useful classification. One class, known as caking coal, fuses when heated, emitting jets of gas, and becoming pasty from the generation of tar-like bodies, which agglutinate the carbon particles, causing them to cohere in lumps and masses over the surface of the grate. The other class, known as non-caking coals, also as free burning coal, burns openly without melting and running together—a peculiarity attributable, perhaps, in a measure, to a deficiency of tarry constituents, and more to a difference in their physical condition.

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Besides the caking coals which are properly considered gas coals, the cannel coals afford to the gas engineer the most important material for his manufacture of gas. Cannel coal is so called from its ready combustion in allusion to a candle, of which the name is a corruption; it is also called parrot coal, from the crackling noise it makes on the fire, suggesting the chattering of a parrot. It yields a large amount of hydrogen, and is properly a hydrogenous coal. The Breckenridge (Ky.) cannel offers a good instance of this property.

PROXIMATE ANALYSIS.

Carbon.....	32.00
Volatile matter.....	54.40
Moisture.....	1.30
Ash.....	12.30
	100.00

ULTIMATE ANALYSIS.

Carbon.....	68.128
Hydrogen.....	6.489
Nitrogen.....	2.274
Oxygen and loss.....	5.833
Sulphur.....	2.476
Ash.....	14.800
	100.00

Cannel coal has been found under water; macerated pulpy masses of vegetable matter have settled to the bottom of some pool or lake, contributing to give it its fine homogeneous texture, and here the slowly evolved products of internal decomposition and combustion, through admission of the oxygen dissolved in the water, have shaped themselves, resulting in a fuel where the hydrogen bears a high proportion to the oxygen and nitrogen.

Dr. McFarlane thus summarizes the features of a gas coal: "The most important requisites of coal gas are, first, that it contains a large amount of volatile combustible matter or gas; second, that the volatile matter be of good illuminating power; third, that the coal be as free as possible from sulphur; and fourth, that the coke furnished by the carbonization of the coal be bulky, and at the same time firm—that is, not inclined to be granular."

Though these facts form a very hasty sketch of the questions involved in the discussion of coal, yet they may assist in explaining the nature, origin, and characteristics of the mineral, which, besides being the basis of gas manufacture, has been termed "the source and guide of civilization."

[From the London "Journal of Gas Lighting."]

British Association of Gas Managers.

Mr. L. Monk (Lanark) prepared the following paper, which was read by Mr. W. Carr (Halifax):

NOTES ON THE RAPID CORROSION OF GASHOLDERS IN HOT CLIMATES.

As the durability of gasholders differs so very much in various climates—being less in hot climates than others—and various opinions having from time to time appeared in print on the subject; and as it is an important and often very annoying subject for not only directors, shareholders, and managers of gas works, but also for gasholder manufacturers, it occurred to me during the delivery of that excellent, instructive, and interesting lecture, at the evening sitting of our last meeting in London, by the late Mr. T. Wills, on "The Products of Combustion," that we had partially a solution of the hitherto apparent mystery, and I thought by enumerating my ideas on the subject, and reading my "notes" at this meeting, a discussion would elicit the information necessary to enable us, under various conditions, to counteract the destructive influence of "combustion" of the iron of gasholders in hot climates. It may appear to you a misnomer, but it seems to me that such is the case, more so than "corrosion" in such climates.

To put the matter more clearly before you, it is necessary that I should quote here the second, third, and fourth paragraphs of Mr. Wills's lecture, as taken from our report of proceedings for 1878, pp. 65–6: "The subject, 'The Products of Combustion,' is a very large one. It includes all the phenomena connected with the formation, nature, and influence of all these bodies which result from the burning of combustible matter. I propose, however, to restrict it to-night to the products of those bodies which are used for illuminating purposes. As it is in the process of combustion that such products are formed, and upon which they are dependent, a knowledge of what is involved in this process is necessary, and to this point, for a few moments, as a preliminary, I propose to ask your attention. When certain

bodies are brought into very close proximity to each other, a combination, or a separation, or a re-arrangement of their constituents takes place. Such an action is called a chemical action, and under whatever circumstances such a chemical action takes place, an invariable result is observed—namely, a development of heat. Such heat is conceived to be due to the rapid motion of the molecules of which the bodies consist. The intensity of this heat varies; but when the motion is sufficiently rapid to give rise to the manifestation of light, combustion is said to occur Now, the amount of heat which can be generated in any chemical action is fixed and definite, and it may be regarded, so to speak, as a potential property of the substance or substances which are undergoing change. It belongs to the matter in which the change is proceeding. But although this heat is an invariable quantity, and its amount cannot be altered by us under any circumstances whatever, the temperature obtained is not at all uniform; that is to say, the temperature manifested in any given chemical action, or even in the same action under different circumstances, is by no means uniform. It is always an expression of the heat evolved, but it is itself variable, and is governed by circumstances. Let me endeavor to make this point clear by illustration. If I take a piece of iron, and permit it to rust in moist air, a certain definite amount of heat is evolved by the chemical action which is going on between the iron and the oxygen of the air. The amount of this heat is dependent entirely on the amount of the iron and the amount of the oxygen which takes part in the action. But if I take such a piece of iron as this [an iron bar], and expose it to moist air, probably there would be no appreciable rise of temperature. I could not, even by the most delicate thermometer, recognize the amount of heat evolved in such a chemical process. But if I took the same weight of iron, and caused it to oxidize in the air under other circumstances, I might so develop the heat evolved in a short time, and in a small space, as to manifest itself, not only by means of a delicate thermometer, but in the visible shape of light. In this tube I have a quantity of metallic iron in a very fine state of division. The tube is sealed at both ends, and the iron is, therefore, out of contact with air. I shall break the tube, empty the contents on to this paper, and I think you will see by the incandescence which occurs with this iron, and possibly the inflammation of this piece of paper, that heat is evolved in this process of oxidizing iron, and the process is identical in every respect with the one which goes on when I oxidize a piece of iron in moist air. [The experiment was performed.] You see here we have the iron made red hot, and the paper itself takes fire. That is only an illustration of what I was saying moment ago, that the temperature may vary, although the quantity of heat would be the same. If the weight of iron which I had in the tube had been exposed to the air in the massive state, until the metal had been converted into oxide of iron, precisely the same amount of heat would have been obtained as in this case; but the light, or manifestation to us of heat, in that action is much greater in this case than in the other. A familiar example of this occurs to me. If we take a piece of wood—say a branch of a tree—and allow it to remain lying on the ground in the forest, it gradually decays. It may take weeks, or months, or possibly years, to decay and pass away into other combinations. If, however, we thrust it into a fire, it burns, giving out heat and light; but the amount of heat in each of these cases will be precisely the same for a given amount of wood. The term combustion is usually restricted to those cases in which the burning takes place with flame. In other words, those cases in which burning bodies are in the gaseous condition. All flames are gaseous flames, and, whenever we have combustion taking place with inflammation, we are dealing with gaseous substances. Now, passing on a step further, and tracing the phenomena upwards, the temperature we can set up in a particular chemical action is an important point. Chemical actions are found to become more and more active as the temperature rises. Two bodies which act upon each other slowly at ordinary temperatures, if heated up to a higher temperature before being brought into contact, will act upon each other much more energetically. Conversely, if we reduce the temperature of the substances which act upon each other, the activity of the chemical action is reduced in the same way; and it is probable that if we could obtain an infinitely low temperature, no chemical action whatever would take place—that is to say, all chemical action might be prevented by lowering down to a sufficiently low extent the temperature of those bodies which would act on each other."

After listening to the lecturer so far, and witnessing the experiment, my opinion was confirmed that the question of the greater or less durability of gasholders in various climates was entirely a chemical question, as is evident by the last paragraph, and caused more or less, as the case may be, by the amount of sulphur and ammonia allowed to get into the gasholders, especially in hot climates; and not, as frequently and erroneously insinuated at meetings of gas companies, that the iron was bad, or damaged by sea water, or other cause, in transit, or carelessness in erection, seriously reflecting on the reputation of firms of the greatest eminence in the world. If I recollect rightly, the Mauritius, Bombay, and Calcutta Companies have had serious losses from this cause, and when the managers find corrosion taking place so rapidly, they resort to the ordinary screw patches and T-headed bolts so commonly used in the United Kingdom, and with which gasholders are employed frequently fifteen years after escapes commence; but instead of a few dozen, these are required by the gross, yet prove of no avail, and the report sent home one year, that, with ordinary repair, the gasholder, though getting leaky, would not require renewal for some years, is followed by another a few months later that a new gasholder is absolutely necessary; thus seriously upsetting the calculations of directors, and causing them to look upon their manager's reports as unreliable.

I may mention, in confirmation of what is here stated, that when in Rome, erecting gasholders, in 1872–3, part of the work in hand was re-sheeting the crown and two top rows of the sides of an 80-feet gasholder, and the crown of another of similar size. Rome was lighted in 1854, and those were the original gasholders. This was the fourth time new crowns had been put in, and the second time of renewing the two top rows of side sheets. Again, in 1875–6, new crowns and top rows of side sheets were required and put on, also a new crown for a 65-feet holder erected in 1872. The whole of the ironwork erected in 1872–3 was of the size and thickness generally used in the erection of gasholders of similar capacity in England, of the best Staffordshire iron, 14 to 10 gauge sheets, according to position, and usually lasting 30 to 40 years in the United Kingdom, and certainly the paint was as fresh as the day when the sheets left the works where the gasholders were made, and no corrosion had taken place from salt water or any other cause in transit.

The question we have to ask then is—What is the cause of this rapid corrosion? It is supposed by many that the imperfect purification of the gas from sulphur and ammonia is the principal cause, the enormous demand for gas suddenly necessitating the overwork of the apparatus on the entry of the Italian Government into Rome a short time previous to 1872, exceeding all the efforts of the engineers, although they had large new works with 100-feet gasholders immediately erected. There the gasholders do not as yet, so far as I am aware, show any sign of corrosion, the apparatus between the retorts and the gasholders being sufficiently large and most elaborate, whereas at the old works it is just the reverse.

I now come to the question of the "combustion" of the iron of gasholders, as the seeming proof of this. Those most exposed to the heat of the sun, and especially the portions of the crowns and sides whereon the sun plays with the greatest effect for the longest time, require renewing first, or rather repairing, and so fast when it commences, that the ordinary T-headed bolts and washers are required by the gross, and soon the crown is not safe to walk on, except with boards under the feet, the fibre of the iron being entirely gone, and merely iron in a powde-ed or oxide state left. Even inside, too, a portion of the framing required renewing after 18 years' work. Further, is it by the combination of impurities in the gas undergoing chemical change by reason of the intense heat upon the crowns, producing combustion; or is it the water in the tank?

We have now to consider, What is the remedy? Would steel plates, charcoal iron sheets, galvanized iron, Bower's or Barff's process of preserving iron from corrosion, or some chemical solution in the water in the tanks prevent oxidation; or is it necessary to cover in the gasholders with houses. And what is the experience of managers in hot climates where the purity of the gas entering the gasholder is beyond question?

I may further mention, in connection with this subject, that when at Amsterdam in 1870, at the works of Messrs. De Bruyn & Sons, a galvanized iron crown was being put on a telescopic gasholder 110 feet diameter, of 10, 11, and 12 gauge plates, according to position, the only one I have ever heard of. On inquiring as to result of the experiment, Mr. Howard, the maker, replied that in his long experience of 40 years as a gasholder manufacturer, it was the only galvanized iron one that he had heard of; it was the opinion of the Engineer that it was very desirable and a matter of economy to have it galvanized; and he had received no complaint or commendation as to the results up to thas time. Probably the Engineer considered it necessary, on account of the rapid corrosion of gasholders by the use of brackish water in the tanks, so common there.

In conclusion, gentlemen, I have to thank you for your forbearance in listening to my rather long notes -paper I may call it, had I written it before sending the title to the Secretary. If any discussion or correspondence on the subject should elicit such information as shall tend to decrease the cost of the wear and tear of such an expensive portion of the plant of gas works as gasholders, and save much labor of many gas managers, my object will have been gained; and I trust the chemical and scientific knowledge of the present day will suggest remedies and instruct many of us in such education and thus enhance the usefulness of this Association.

DISCUSSION.

Mr. P. H. Wilkinson (Harrogate) said about eleven years since, after a good deal of corrosion of the purifier-covers, he put in a galvanized iron top and since then he had no trouble with it; and, so far as he had seen, there was no apparent corrosion. They were now putting up new purifiers made of galvanized iron.

Mr. T. Newbigging (Manchester) said that although this paper might not appear of much immediate value, it should be remembered that gas-works were now widely spread over the entire world. Englishmen being mostly called upon to manage them; and it might be the fortune, or misfortune of some of those present to have to go abroad into a hot climate, and superintend gas-works, when they would be able to appreciate the hints and suggestions contained in a paper of this character. He had a very unfortunate experience with a gasholder when abroad, and to this hour he had never been able to account satisfactorily for its rapid deterioration. He did not think that Mr. Monk covered the whole ground of the subject in his paper, for this reason, that in the instance he (Mr. Newbigging) referred to, it was not the crown nor the sides exposed to the heat of the sun which deteriorated, but the sheets near the bottom, which were usually immersed in the water. He put up a new gasholder in Brazil in 1872, and when he left that country in 1875, the holder, which was of first-class construction, was rapidly going to decay. The only way in which he could account for it was that the tank was of cast iron, and as they had to use brackish water in the tank, having no fresh water, it is probable galvanic action was set up between the cast iron in the tank and the wrought iron in the gasholder through the medium of the brackish water. It was not, he believed, oxidation at all in the ordinary sense of the term which caused the destructive action, because it commenced and was continued entirely from the inside, working its way outwards. On the outside the holder was perfectly sound. It was first painted, and had afterwards several good coats of tar, and eventually it might almost be said that the tar constituted the lower portion of the holder, because it was actually found that the finger could be pushed through the lower portion of the side of the vessel, and the sheets torn like brown paper.

The President said he presumed the purifying plant was of sufficient capacity.

Mr. Newbigging said the purification, as regarded sulphuretted hydrogen, was perfect. He erected a washer also, because washers in a hot country were indispensable, and he cleared out the ammonia pretty completely—as well as it could be done in a hot climate.

Mr. J. Hammond (Lewes) said the best purified gas always contained a certain amount of sulphur, and he thought it would be found that the moisture raised by the sun in a hot climate, diffusing itself throughout the gas, reproduced itself in the presence of the sulphur, and decomposed the water, splitting it up into hydrogen and oxygen. In that direction, he thought, they might look for an explanation of the rapid destruction of iron.

Mr. Newbigging said in the case he referred to it was not the sheets exposed to the heat of the sun that were destroyed, but those at the bottom, which were usually immersed in water.

Mr. W. Barratt (Grantham) said he had three gasholders, one nearly 30 years of age, and he had noticed it frequently. Some of the sheets were pretty nearly done for—eaten completely through from the outside, whilst others did not appear to be at all affected by the action of the atmosphere, or gas, or water, or anything else. He was distinctly of opinion that it was the quality of the iron of which the sheets were composed that caused this rapid corrosion. He did not know what it might be in hot climates, but for the first few years after the holder referred to was erected, he was informed that it was well coated with the very best white lead and boiled oil, and he found that wherever that white lead and boiled oil continued to adhere to the sheets they were as good apparently as when they were put in.

Mr. J. White (Seaham) thought the last speaker was in the right, and that more depended on the quality of the iron than anything else. In one place where he was managing some gas works, one of the holders was 12 years old, and in the crown there were not less than 500 leaks; another was 40 years old, and did not show a particle of leakage, which was a clear proof that more depended upon the quality of the iron than anything else.

Mr. W. Foster (London) said it was generally admitted by chemists that two agencies were required for the corrosion of iron. Atmospheric oxygen, perfectly dry, was incapable of acting on iron, and, on the other hand, the late Dr. Grace Calvert made a number of experiments showing that iron perfectly bright, when immersed in water, boiled so as to expel the whole of the air, was incapable of oxidizing. It was the joint action of the two—air and water—which caused oxidation; so that he should think it was more to the surface of the iron being well coated by an impervious agent that they should look to prevent this corrosion. Once corrosion commenced it soon ate its way through. There was no doubt that the oxygen in gas would contribute to this result, although it might be in small quantities, and the water in the gasholder tank would contain oxygen, in consequence of the solubility of oxygen in water.

Mr. W. Cleland (Linacre, Liverpool) said there was no doubt that in the interior, as well as outside of the gasholder there was free oxygen which, in the presence of moisture, and under the influence of heat, would tend to oxidize the iron; something was due probably to the quality of the iron. The presence of carbon in cast iron apparently resisted the action of oxygen upon it. It seemed to him that as the primary cause of corrosion was oxidation, the most likely way to prevent it would be to combine beforehand a certain proportion of oxygen with the plate, as was done in Professor Barff's process, covering the surface with a magnetic oxide, which formed an impervious and permanent anti-corrosive coating. He had not much faith in galvanized iron, because, although he had observed that, in some cases, after being many years in use, the sheets were as sharp at the edges as when they were galvanised, yet in other cases they perished in a few years. He had little confidence in coating holders internally with any kind of oil-paint, because, in truth, the gas generally destroyed it very soon.

Mr. G. B. Irons (Gosport) said his experience of gasholders was principally in the South of England. The crown of one of their new gasholders was very much corroded, and the outside wall covered with paint, but they found a large number of leaks on it. On opening the crown to put in new sheets, he noticed that there were lots of small pinholes, through which the leaks took place. There were also a series of small streaks on the sheets, which led him to agree with the gentlemen who had spoken of the effect of evaporation. He had little doubt that it was the evaporation and recondensation of the water upon the interior of the crown of the holder, and its trickling down, which gradually ate into the surface of the iron, and, perhaps, there might be some little inequality in the purity of the sheet itself, where it ate through very rapidly as all the leaks were in these streaks.

Mr. Carr said no doubt this part of the discussion would be valuable to some of their members who could not attend the meeting, and he was glad Mr. Monk had brought forward a subject which would be of interest to those whose business took them abroad. Mr. Newbigging's observations added to their knowledge, but did not dispose of the argument of the paper at all, being merely a new kind of experience. In his opinion, the difficulty in the case referred to by that gentlemen must have arisen from something which the water contained. He said that the water was brackish, and possibly it contained something which acted energetically on the iron plates immersed in it. He did not think it could be galvanic action between the cast and wrought iron, unless there was something in the water to promote that action. What Mr. Monk contended for was—and that had been proved to be the case by Mr. Hammond and Mr. Foster—that there was evidence of a slow combustion of the iron, and it was well known that combustion always took place more rapidly at a high temperature than at a low one. Mr. Monk's contention was that the excessive heat to which the crowns of the gasholders were exposed promoted a greater degree of corrosion, or greater rapidity of combustion than occurred here, and it was not the quality of the iron that was at fault; otherwise it would be a very curious set of circumstances which occurred in Rome, for instance, where they must have had bad iron five or six times successively. Besides, he did not know that bad iron was more liable to corrosion than good iron, and was rather of opinion that all classes of iron would rust pretty nearly alike if exposed to the same conditions, unless subjected to some particular kind of protection. He was glad Mr. Cleland had referred to the coating of iron with magnetic oxide, and if there was any preparation to which iron could be subjected with a view to preserving it in a hot climate, it would be a great boon to all those who were engaged in those distant parts of the world. The causes which Mr. Monk referred to were those in which the crown went first, whilst the sides remained tolerably sound, and in some cases the crown had to be renewed several times, which was a great misfortune to the gas company, because of course that would not be done until the company had lost a great deal by leakage.

The President said there could not be a doubt that it was a most important matter, and as yet, neither by experience nor theory, did anything appear to have been stated which would fully explain it. Mr. Monk's experience showed him that the tops of the gasholders were affected most by this action, whatever it might be, whilst Mr. Newbigging's was quite the opposite. With regard to the quality of the iron, one could not think for a moment that there could be such a great difference in the quality of iron used here and abroad, although it might possibly be that the surface was in the transit destroyed or injured.

San Francisco Water Supply.—San Francisco is largely supplied with water by artesian wells, of which it is said there are not less than 200 in the city. While in London and elsewhere it has been observed that the supply of each well decreases in proportion to the increase in the number of wells, such an effect has not been observed in San Francisco. In some of them the water is reached at a very small depth. One of the hotels is supplied by a well 38 feet deep. Another has a well 60 feet deep, furnishing 6,000 gallons of water per day. A candle factory has a well 168 feet deep, which gives a supply of 10,000 gallons per hour. The *Chronicle* has been putting up a building, for which a new well is being bored, which is expected to supply 8,000 gallons per day. One reason for the large number of artesian wells in the city has been the extortionate rates charged for water by the corporations through which the city has received its supply. Like nearly all the corporations of California, these water companies have manifested an intolerably insolent and rapacious disposition.—*Engineering News.*

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TUESDAY, SEPTEMBER 2, 1879.

Official Report of Examinations of Gas for three Weeks ending Aug. 30, 1879, made at the Photometrical Room of the Department of Public Works.

Corrected Illuminating Power.

Aug. 1879.	Time of Day at which Test were made.	New York Gas Light Co.	Manhattan Gas-Light Co.	Mutual Gas-Light Co.	Metropolitan Gas-Light Co.	Harlem Gas-Light Co.	Municipal Gas-Light Co.
11	Between 9.30 A.M. and 1 P.M.	17.06	17.55	19.40	17.85	16.66	
12		16.87	16.85	18.98	17.90	16.34	
13		16.82	17.74	17.98	17.95	16.06	
14		16.96	16.97	18.31	18.08	16.40	
15		17.06	17.10	17.91	17.79	16.44	
16		16.76	16.51	17.78	18.09	16.22	
	Average	16.92	17.12	18.39	17.94	16.35	
18		16.92	17.14	17.57	17.82	16.14	
19		16.88	17.45	18.08	17.60	16.12	
20		16.53	16.94	18.32	17.90	16.61	
21		16.55	17.14	18.34	18.15	16.56	
22		16.22	16.78	18.34	17.60	16.33	
23		16.21	17.17	18.67	18.47	16.48	
	Average	16.55	17.10	18.22	17.92	16.37	
25		16.01	16.92	18.87	17.37	16.05	
26		16.57	17.21	18.30	17.56	15.98	
27		17.17	17.05	18.57	17.54	16.40	
28		16.84	17.11	18.44	17.65	16.46	
29		16.45	17.21	18.75	17.71	16.38	
30		16.46	16.71	18.88	17.07	16.09	
	Average	16.58	17.03	18.63	17.48	16.22	

Sugg-Letheby burner.

E. G. LOVE, Gas Examiner.

Transmission of Power to Long Distances by Gaseous Fuel.

The success of a recent experiment in France in the use of electricity as a means of transmission of power applied in plowing has given rise to considerable discussion in our foreign exchanges. The plowing machines were such as are commonly used in England, in which portable engines are placed at each end of the field, and the plows drawn to and fro by ropes stretched between windlasses on the engines. In this case a steam engine at a distance was caused to operate a dynamo-electric machine, the current from which was carried by wires to two electro-dynamic machines at each end of the field, taking the place of the usual engines, and there re-transformed into mechanical work and caused to give motion to the windlasses which drew the plows. The experiment showed that at a distance of about a mile the work realized by the electro-dynamic machinery was from 40 to 50 per cent. of that done upon the dynamo-electric machine in which the mechanical work was transformed into electric current. The success of this experiment seems to open a wide field for the application of electricity to the transmission of power for a great variety of purposes, and the long talked of utilization of the power of Niagara Falls may yet be realized by this means. The great loss of power in transmission, however, as well as the expensive apparatus required, will greatly restrict the application of this system, and it is no more likely to become the universal method of transmission than is water pressure, compressed air, or transmission by wire ropes.

The articles which have recently appeared in the *Manufacturer* concerning cheap gaseous fuel suggest to us another means of transmission of power to long distances, which it appears to us is much more likely to come into general use than either of the methods mentioned above. This means is the carrying of the power in the shape of fuel, instead of carrying it as pressure, as in the water pressure or compound air systems, as mechanical work as in wire rope transmission, or as electric current in the dynamo-electric system. The fuel, gas, can undoubtedly be carried with less loss by friction than water under pressure, with less loss by radiation of heat than compressed air, with less loss by wear and tear and friction than the energy in a wire rope, and with less loss by conduction or other causes than an electric current. It only remains to find a method of transforming the fuel into mechanical work at the point at which it is to be applied, by some machine which shall be entirely portable and not too costly. The fulfilling of all the requirements is perhaps not yet in in existence, but as soon as cheap gaseous fuel is made a reality it will not be long until our inventors have designed apparatus in which it may be utilized for every purpose for which mechanical power is needed. The Otto gas engine, or other similar gas engines, it will probably be found will be better adapted to the use of gaseous fuel than are steam engines, with their cumbersome and dangerous steam boilers.

We may look forward to the day when the farmer will have his plows drawn by two small engines driving a windlass at each end of the field, and a rubber hose carrying gas to these engines from the same gas generator which supplies light to his home. A portion of the same gas may be used to run a miniature engine attached to the sewing machine, and another portion used to do the household cooking. We present to our inventors the problems of the utilization of gaseous fuel for domestic and agricultural purposes, and of its use as a general method of transmission of power to long distances, as two of the most important problems which can engage their attention.

Still another problem may be solved by the combination of gaseous fuel with small engine, viz., the sub-division of the electric light. The miniature engine spoken of as driving the domestic sewing machine may drive a small dynamo-electric machine, and the current from the latter run a small electric light suitable for household and other porposes.—*American Manufacturer.*

Coal Gas vs. Water Gas.

The Manhattan Gas Light Company have issued the following circular:

"The Municipal Gas Light Company having appealed to the consumers of gas and the public generally, asking them not to lend their support to the Manhattan Gas Light Company, we are compelled in self defense to expose the misstatements of that company with regard to the quality and value of the gas furnished by them.

"It is not true, as stated by them, that their gas is from 20 to 30 per cent. cheaper to the consumer than the gas supplied by this company. It is not true that their gas posseses an illuminating power higher than that of the Manhattan Company. Tested by the same burner, the gas of the Manhattan Company is fully equal to that of the Municipal Company, and requires no greater quantity to produce the same amount of light.

"The gas supplied by the Manhattan Company is far safer and purer, and as economical as that which the Municipal produces. Careful analyses by the eminent chemist, Prof. Henry Morton, President of Stevens Institute of Technology, and others, show the Municipal gas to contain 26 to 30 per cent. of carbonic oxide, one of the most poisonous gases that can be inhaled, insidious in its nature, and destructive of health and life, even when taken in small quantities.

"In burning the Municipal gas, more carbonic acid is produced, and more oxygen required, thus vitiating the air in the room to a much greater degree than the gas furnished by the Manhattan Company.

"The Manhattan Gas Light Company is not and never has been, as stated by the Municipal Company, a monopoly; it never had any exclusive rights, and never asked for any; it has always rejected the schemes and pretentions of mere speculators, water gas among the number, and sought to avail itself of all known improvements in science; it has always relied upon the quality and purity of the gas supplied to the public, and will continue to do so, confident of receiving the support of all who desire the best that can be produced at the lowest possible price.

"JAS. SMITH, *Sec.* CHAS. ROOME, *Pres.*"

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AUGUST 16, 1879.

☞ All communciations will receive particular attention

☞ The following quotations are based on the par value of $100 per share.

Gas Co.'s of N. Y. City.

	Capital.	*Par.*	*Bid.*	*Asked.*
Central	466,000	50	60	75
Harlem	1,800,000	50	40	45
" Bonds	170,000			103
Manhattan	4,000,000	50	145	150
Metropolitan	2,500,000	100	115	120
" Scrip	$1,000,000	..	100	103
Mutual	5,000,000	100	50	55
" Bonds, gold	900,000	1000	100	105
Municipal	1,500,000	100	115	120
" Bonds	750,000		105	110
New York	4,000,000	100	87	90
Northern	270,000	50	—	100

Gas Co's of Brooklyn.				
Brooklyn	2,000,000	25	110	115
Citizens	1,200,000	20	50	60
" S. F. Bonds.	320,000	1000	100	102
Peoples	1,000,000	10	18	25
" Bonds	325,000	...	--	95
" Scrip	300,000	...	75	80
Metropolitan	1,000,000	100	40	50
Nassau	1,000,000	25	50	60
" Ctfs.	700,000	1000	80	85
Williamsburgh	1,000,000	50	70	75
" Scrip		...	90	95
Kings Co	200,000	100	—	70
Union Co. E. N. Y.		25	—	50
Richmond Co., S. I.	300,000	...	60	85
Out of Town Gas Companies.				
Bath, Maine	70,000	100		
Buffalo Mutual, N.Y	750,000	100	65	70
" Bonds	200,000	1000	95	100
Baltimore, Md	2,000,000	100	95	98
" Ctfs., gold	1,000,000		95	10
Bayonne, N. J		100		90
Brockport, N. Y	25,000	100	...	80
Citizens, Newark	918,000	50	100	103
" " Bds.	124,000	—	105	10
Chicago Gas Co., Ills			128	130
Cincinnati G. & C. Co.				190
Derby of Conn	160,000	100	60	80
East Boston, Mass		25	114	120
Elizabethtown, N. J.	300,000	20	—	130
Fort Wayne, Ind.		100	...	—
Hannibal, Mo	100,000	100	95	100
Hartford, Conn	700,000	25	120	125
Hempstead, L. I.	25,000	100	...	—
Jersey City	750,000	20	145	155
Jamaica, L. I.	25,000	100	...	—
Jacksonville, Ill.	120,000	50	100	...
Lewistown Maine	400,000	100	70	80
Lima, Ohio,	60,000	100	--	...
Bonds	30,000		90	
Laclede St Louis Mo.	1,200,000	100	—	75
Long Branch		20	30	40
New Haven, Conn		25	152	—
Peoples, Jersey City		...	—	80
" " Bds.				95
Peoples of Albany	650,000	100	—	10
" Bonds	350,000	1000	--	-
Peoples of Baltimore		25	44	48
" Bonds			106	—
Plainfield, N. J	80,000	100	—	105
Perth Amboy		25	—	95
Rochester, N. Y.		50	70	80
" Citizens		100	50	60
Toledo, Ohio			95	97
Washington, D. C	1,500,000	20	—	200
" Scrip	500,000	20	100	—
Yonkers		50	70	80
Woonsocket, R. I.	150,000	100	80	...
Halifax N. S.	400,000	40	148	150
Hamilton, Ontario	150,000	40	117½	
Pittsfield, Mass			120	130
Rondout & Kingston			75	80
St. Louis Missouri	600 000	50	72	75
Stillwater, Minn	50,000	50	—	26
Saugerties, N. Y	15,000	100	95	100
Troy, Citizens	600,000	100	—	60
San Francisco Gas-Co., S. Fr'isco Cal.			95	95¼

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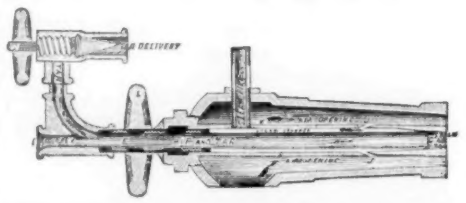

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Duration and mode of testing in London, sulphuretted hydrogen, ammonia, sulphur compounds. Preparation of solutions. Fitting up. To set the apparatus at work. Analysis.

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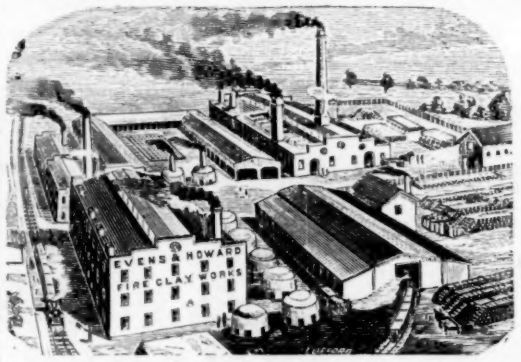

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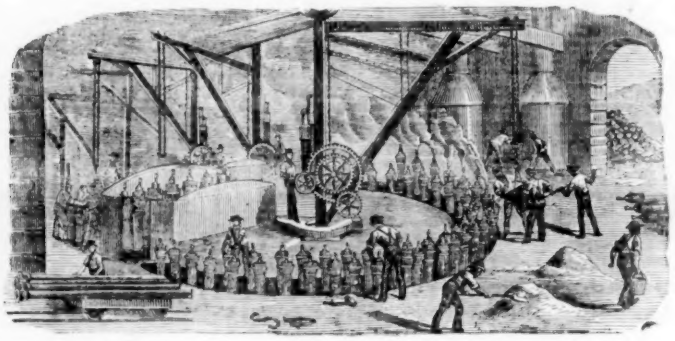

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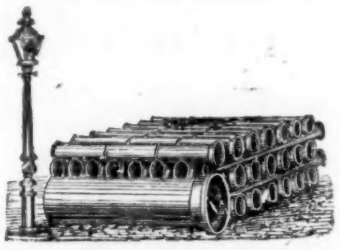

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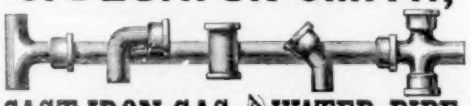

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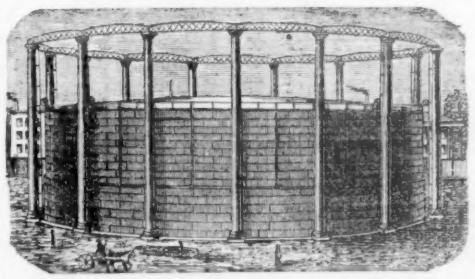

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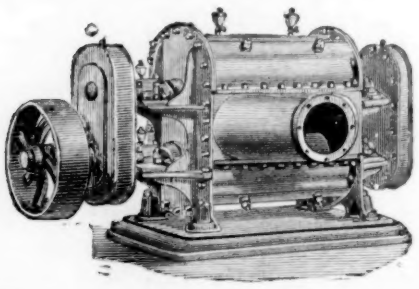

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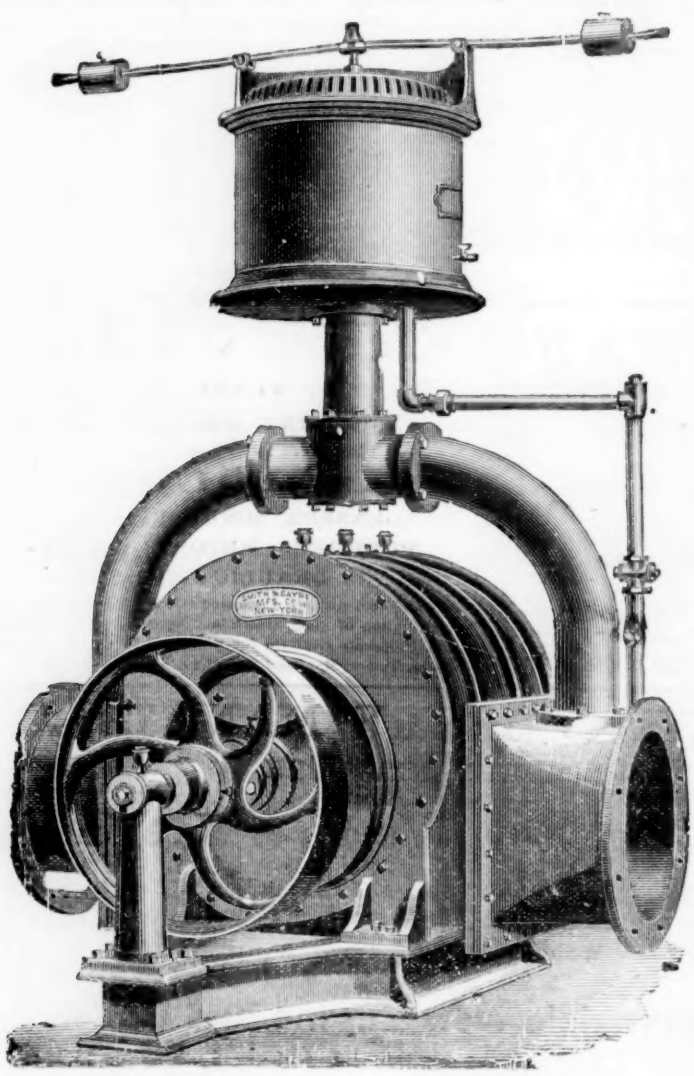

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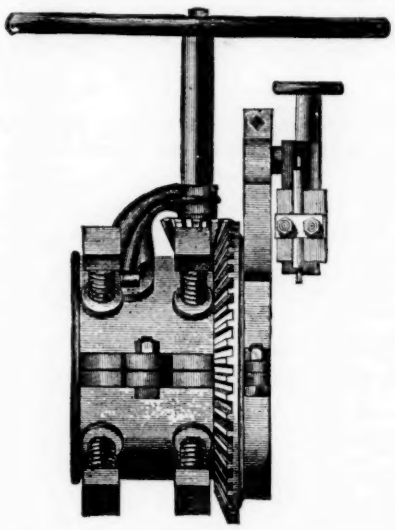

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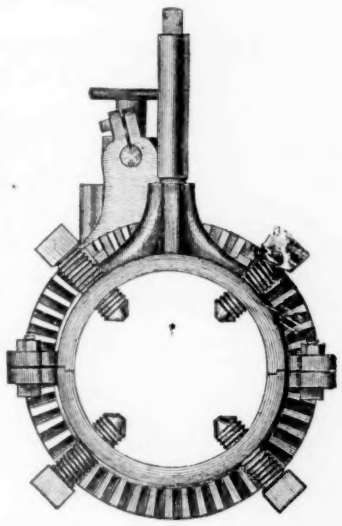

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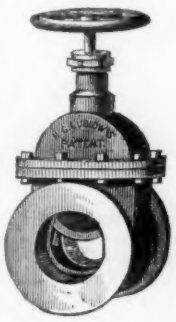

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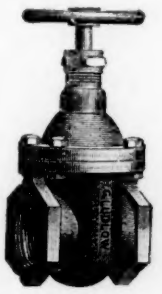

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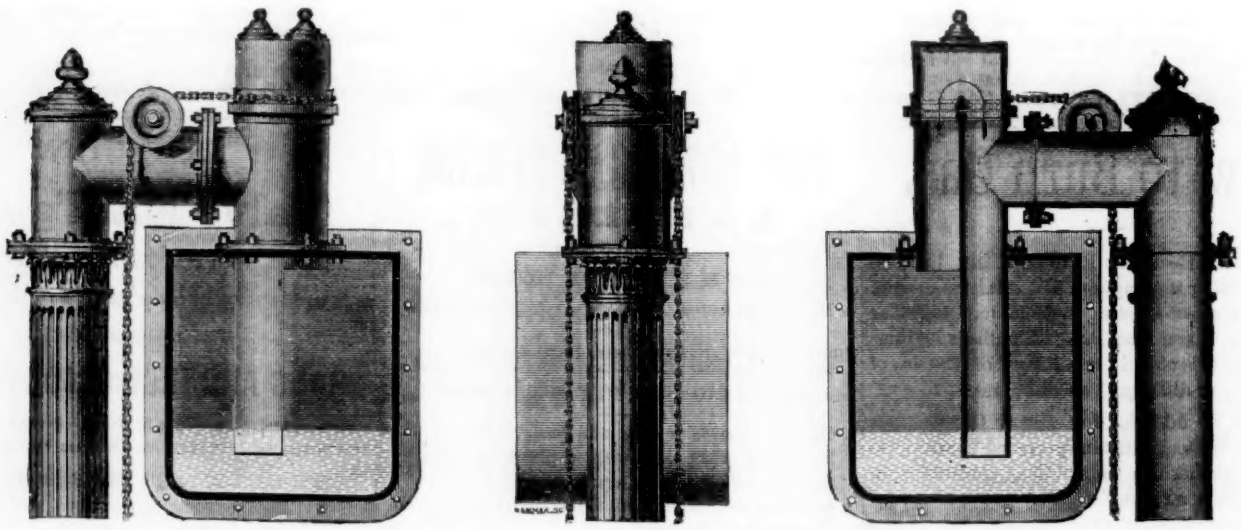

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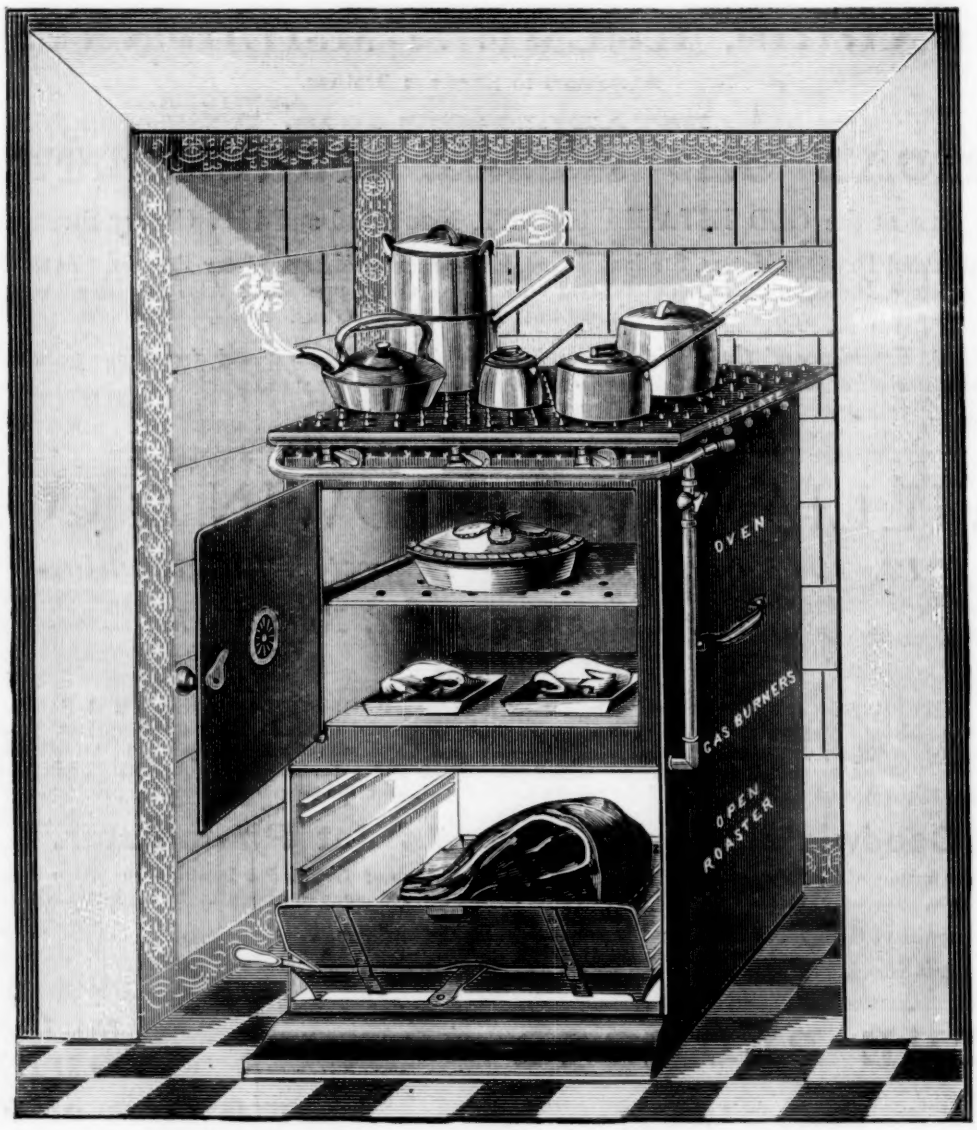

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